PHASE ONE REPORT

National Fire Coordination Study

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/DIVISION OF FIRE CONTROL

PHASE ONE REPORT

By

William R. Moore
James W. Jay
John H. Dieterich

A Working Paper Prepared by the

National Fire Coordination Study Group
May 1965

This report is a working paper containing the authors' preliminary analysis and recommendations concerning certain aspects of the nuclear fire problem in urban and rural areas. The contents do not necessarily reflect the policies of the Office of Civil Defense or the Forest Service.

Prepared by USDA, Forest Service, Division of Fire Control, Washington, D. C., for the Office of Civil Defense under Item 1 Project Order OCD-PS-64-229.

PREFACE

This report culminates the Analytical Phase of the National Fire Coordination Study, which is being done by the Forest Service for the Office of Civil Defense. Objectives of the fire study are to: (1) Review pertinent research findings and define the Nuclear Fire Problem; (2) recommend a nationwide fire defense program, including alternatives, for the Office of Civil Defense; and (3) recommend how the several parts of the fire defense program should be implemented.

Many sources of information were used by the study staff to identify the fire defense problem and to evolve recommendations. These sources are listed in the references but individual citations are not given in the body of the text.

The report examines the nuclear fire problem, establishes the basis for a fire defense program, examines potential elements for fire defense, and suggests alternative fire defense programs made up of combinations of these elements. It is a working paper intended to help the Office of Civil Defense plan the fire defense program and to provide a basic reference for those engaged in planning and implementing the approved fire defense program.

MERLE S. LOWDEN, Director
Division of Fire Control
United States Forest Service

ACKNOWLEDGMENTS

The National Fire Coordination Study staff could not have accomplished the Phase One analysis and recommendations without the guidance of many dedicated and capable persons in the fire services, fire organizations, fire educational institutes, the Office of Civil Defense, and other Government agencies.

John J. FitzPatrick, William K. Chipman, and John F. Vaccara of the Office of Civil Defense gave invaluable overall guidance.

Jim Kerr and John Christian, Office of Civil Defense, Ted Storey and Craig Chandler of the Forest Service made special contributions to the review and interpretation of research findings.

Special thanks are extended to the following men who, as a group, helped develop the recommendations published in this report.

Chief Milton Bullock
Metropolitan Dade County Fire Department
Miami, Florida

Mr. Donald O'Brien, Editor
Fire Engineering Magazine
New York, New York

Chief Edward P. McAniff
New York City Fire Department
New York, New York

Chief Noel Manchester
Los Angeles County Fire Department
Los Angeles, California

Mr. Donald Drumm
American Insurance Association
New York, New York

Mr. James Franks
Bureau of Land Management
Department of Interior
Washington, D. C.

Mr. Keith Royer, Supervisor
Fire Service Extension
Iowa State University
Ames, Iowa

Chief David B. Gratz
Silver Spring Fire Department
Silver Spring, Maryland

Mr. Lee C. Fine
Missouri Conservation Commission
Department of Forestry
Jefferson City, Missouri

Mr. Paul Lyons
National Fire Protection Association
Boston, Massachusetts

Mr. William Johnson, Fire Chief
Maryland Department of Parks and Forests
Annapolis, Maryland

Mr. George Moorhead
New Jersey Bureau of Forestry
Trenton, New Jersey

Special thanks are also extended to the many persons who contributed their time and ideas to the briefing meetings at the beginning of the study; those who critically reviewed early drafts of the Phase One report; the able consultants and contractors who brought their capabilities to bear on the problem; the National Fire Protection Association personnel, who supplied invaluable guidance and library services; the many local officials who helped us with field studies; and the managers of going fires who, even during the stress of fire emergency, found ways for our analysts to make effective fire studies.

CONTENTS

Section		Page
I.	INTRODUCTION	1
II.	SUMMARY OF ANALYTICAL RESULTS	5
III.	SUMMARY OF RECOMMENDATIONS	10
	AUSTERE FIRE DEFENSE PROGRAM	13
	MODERATE FIRE DEFENSE PROGRAM	16
	COMPREHENSIVE FIRE DEFENSE PROGRAM	19
IV.	THE NUCLEAR FIRE PROBLEM	21
	ASSESSMENT MODELS	22
	EFFECTS OF ATTACK	24
	SUMMARY	27
V.	EXISTING FIRE DEFENSE CAPABILITIES	28
	PRE-EMERGENCY READINESS	28
	CAPABILITY DURING FIRE EMERGENCIES	30
	NUCLEAR VS. PEACETIME FIRE CONTROL REQUIREMENTS	31

CONTENTS

Section		Page
VI.	POTENTIAL ELEMENTS OF A FIRE DEFENSE PROGRAM	33
	PROTECTION MEASURES	35
	Reducing the Number of Ignition Points	35
	Citizens' Fire Extinguishing and Prevention Program	36
	Treating Combustible Furnishings with Fire Retardant Chemicals, or Covering them with Fire Retardant Sheets	38
	Reducing Thermal Effects	39
	Smoke Screening	40
	Window Shielding	41
	Reducing the Vulnerability of Fallout Shelters to Fire	44
	Inspecting and Rating Shelters	45
	High-Expansion Foam Extinguishers in Shelter Buildings	47
	Shelter Fire Control Training Kit	47
	Organized Fire Suppression and Rescue	48
	Infrared Mapping of Nuclear Fires	58
	Use of Aerial Fire Retardants in Protecting Shelters from Fire	61
	Using Aircraft as a Tool for Fire Defense	62
	Special Equipment for Suppressing Nuclear Fires	64
	Citizen Support for the Fire Services	68

CONTENTS

Section		Page
	Measures for Reducing Fire Spread	69
	Community Planning to Minimize Fire Spread	69
	Reducing Fire Spread Potential in Rural Areas	70
	SUPPORT PLANS	71
	Nuclear Fire Analysis	74
	Components of the Nuclear Fire Analysis	76
	Implementing the Nuclear Fire Analysis	76
	Costs & Impacts of the Nuclear Fire Analysis	78
	Plans for Fire Defense	79
	Guides for Community Planning to Minimize Urban Fire Spread	83
	Nationwide Fire Intelligence System	84
	Nationwide Fire Communications System	86
	Scope, Content, and Plans for a Nationwide Communication System	87
	Standard Fire Terminology for the United States	88
	Fire Service Radio Operating Procedures Handbook	89
	Professional Fire Staff Leadership	90
	TRAINING	92
	National Fire Technical Staff Support Center	93
	Nuclear Fire Leadership Training	96
	National Nuclear Fire Leadership Training	96
	Local Nuclear Fire Leadership Training	98

CONTENTS

Section		Page
	Organized Citizens' Fire Defense Training	100
	Fire Defense Support Firemen Training	101
	Rural Fire Defense Training	104
	RESEARCH AND DEVELOPMENT	105
	Knowledge Gaps	107
	Special Studies, Methods Development, and Equipment Development	109
VII.	THE RECOMMENDED FIRE DEFENSE PROGRAM	112
	RECOMMENDATIONS	112
	THE AUSTERE FIRE DEFENSE PROGRAM	113
	Initial Phase	115
	Interim Phase	117
	Full Development Phase	119
	THE MODERATE FIRE DEFENSE PROGRAM	121
	Initial Phase	121
	Interim Phase	123
	Full Development Phase	125

CONTENTS

Section		Page
	THE COMPREHENSIVE FIRE DEFENSE PROGRAM	127
	Initial Phase	127
	Interim Phase	130
	Full Development Phase	131
	DEFINING THE OPTIMUM FIRE DEFENSE PROGRAM	133
VIII.	COST AND EFFECTIVENESS	136
	COSTS OF THE RECOMMENDED FIRE DEFENSE PROGRAMS	137
	COSTS OF PROGRAM ELEMENTS CONSIDERED BUT NOT RECOMMENDED	144
IX.	IMPLEMENTING THE PROGRAM	148
	THE ROLE OF THE FIRE SERVICES	148
	IMPACTS ON EXISTING SYSTEMS	150
	Impacts on the Total OCD Organization	150
	Impacts on the Priority Programs Included in Part B, Chapter 3, Appendix 2, Federal Civil Defense Guide	152
	Other Impacts	153

CONTENTS

Section		
X.	SPECIAL PROBLEMS	157
	PROTECTING FIRE CONTROL EQUIPMENT FROM BLAST DAMAGE IN URBAN AREAS	157
	Dispersing Fire Equipment on the Basis of Warning	157
	Blast Hardening of Firehouses	159
	TACTICAL NUCLEAR DISASTER MANAGEMENT	159
	REFERENCES	164
	APPENDIX	166
	DEFINITIONS	166

LIST OF FIGURES

Number		Page
1	Relative size of alternative fire programs	11
2	Effects of nuclear attack on total land area of the United States	26
3	Life saving potential of fallout shelter system in attack against Military - urban - industrial targets	34
4	Effects of light attack by nuclear weapons on City "C"	51
5	Effects of light attack by nuclear weapons on City "A"	54
6	Effects after the first wave of medium-heavy attack by nuclear weapons on City "A"	55
7	Effects after the second wave from medium-heavy attack by nuclear weapons on City "A"	56
8	Relative size of fire defense programs and of training, plans and protection measures	73
9	Cost-effectiveness of hardening fire houses	160

LIST OF TABLES

Number		Page
1	AUSTERE OCD Fire Defense Program	14
2.	MODERATE OCD Fire Defense Program	17
3	COMPREHENSIVE OCD Fire Defense Program	20
4	Estimated frequency distribution of ignitions per block at fire front	65
5	Summary of findings of mutual aid and command studies	81
6	Elements of the AUSTERE Fire Defense Program	114
7	Elements of the MODERATE Fire Defense Program	122
8	Elements of the COMPREHENSIVE Fire Defense Program	128
9	Costs for elements of recommended programs	138
10	Time-phased cost summary for three alternative programs (OCD costs)	139
11	Time-phased summary of OCD costs in AUSTERE Program	140
12	Time-phased summary of OCD costs in MODERATE Program	141
13	Time-phased summary of OCD costs in COMPREHENSIVE Program	142
14	Cost of protection measures considered, but not recommended	145
15	Usability of deployed equipment following heavy and light attack - three cities	158

I. INTRODUCTION

BACKGROUND

The National Fire Coordination Study, started in June 1964, by the Division of Fire Control of the Forest Service for the Office of Civil Defense, seeks to investigate, describe, and recommend the most practical program of protective measures and operational planning that should be undertaken for the fire defense of the Nation in the event of nuclear attack. The overall study is in two phases.

This report (Phase One) is based upon the findings of a series of pertinent analyses that were conducted in support of the Project; it provides data necessary for an understanding of the overall problem and suggests several alternative fire defense programs of varying cost, complexity, and effectiveness After the alternative programs have been reviewed and evaluated by OCD, the second phase will commence. The report to be issued at the completion of Phase Two will provide the specific guidelines and analyses for the fire protection measures and supporting plans that have been selected. It will contain outlines of course content, scope, and procedures involved in establishing the training required to carry out the recommended program.

APPROACH

The National Fire Coordination Study Group performed several analytical investigations as part of their Phase One study. Three hypothetical nuclear attacks were simulated and used with previous completed research findings as a basis for defining the nuclear fire problem.[1/] Additional data were developed by studying mutual aid and command arrangements in Oregon, California, Michigan, Massachusetts, and the Washington, D. C. metropolitan area. Operations on four large and varied fires were studied. Previous recommendations from pertinent studies and research papers were analyzed. Briefings and problem-solving meetings were held with professional fire service personnel. Data developed from these meetings and studies were related to the nuclear fire problem and are the basis for the fire defense programs recommended in this report.

1/ Fire threat to lives and resources stemming from nuclear attack complicated by accompanying blast and fallout.

Fallout shelters are recognized as the basic measure necessary for saving lives after a nuclear attack. The first purpose of the fire defense program is to save the lives of blast survivors within fallout shelters threatened by fires. The potential of the program is expressed in terms of sheltered survivors protected from subsequent fire threat. Effectiveness of the fire program for saving resources essential to recovery of the Nation has not been assessed, but undoubtedly the potential is substantial.

ORGANIZATION OF REPORT

This report presents results of Phase One of the National Fire Coordination Study. It summarizes the results of the supporting analytical investigations, provides a basis for the development of the specific elements of a unified fire defense system, and integrates the most promising features into several alternative OCD Fire Defense Programs.

The most salient findings of the analytical investigations are summarized in the next section. These are followed by a summary of recommendations in which three over-all fire defense programs, corresponding to three levels of effort and investment, are presented.

The remainder of the report presents substantial supporting information and pertinent details. It summarizes and presents data pertinent to the nuclear fire problem and on existing capabilities for fire defense. It discusses potential elements of a future fire defense program in detail and presents the recommended fire defense program. Cost data on the various program features are elaborated. It treats various aspects of implementing the program, including possible impact on existing systems as well as the role of the fire services in the program. Finally, it briefly discusses special problems, including those related to the fire problem but beyond the scope of this report.

II. SUMMARY OF ANALYTICAL RESULTS

The analytical study shows that fire is a significant causative agent in the loss of lives and resources resulting from a nuclear attack. However, when the population is in residences,[1/] fire is a lesser threat to lives than blast and fallout. This is because the overwhelming effects of blast and fallout leave fewer persons alive to be threatened by fire. Conversely, the threat from nuclear fire is dangerous for a well-sheltered population. If shelters are available and used, more persons would survive the effects of blast and radioactive fallout; thus more persons would be alive to be threatened by fire. Depending on weather conditions and the weight and nature of a nuclear attack, as much as 10 percent of the land area of the United States could burn; this would threaten communities and resources needed for the Nation's recovery. In addition, confusion, created by smoke and havoc from these large fires, could result.

1/ Blast and fallout protection in residences is considered in relation to typical building design.

COPING WITH THE FIRE THREAT

Several measures, when combined into a coordinated program, could reduce the fire threat. These include measures to: (1) reduce the number of potential ignition points, (2) reduce thermal effects, (3) reduce the vulnerability of fallout shelters and adjacent structures to fire, and (4) apply selective organized fire suppression and rescue procedures.

Support programs necessary to make these measures effective include an analysis of the nuclear fire potential for each community, planning for fire defense, developing equipment, making operational studies, and training personnel.

There is a long-range potential to reduce the fire threat by guiding the planning of cities to minimize fire spread and developing more effective ways to convert research findings to operational action.

ROLE OF THE FIRE SERVICES

Organized fire services can provide leadership to a trained public and can take fire control and rescue actions to reduce the hazard to lives from nuclear fire. Fire services cannot be expected to handle fully all fires resulting from a nuclear attack. Actions of fire services will be most effective if

supported by informed pre-attack planning and preparedness. Planning and preparedness by the fire services must recognize that firefighting and rescue following nuclear attack will be far different from normal tasks. The role of the organized fire services will vary by communities.

EFFECTIVENESS OF FIRE DEFENSE PROGRAMS

The extent and timing of the Office of Civil Defense Fire Defense Program will be affected by available finances and an acceptance and understanding by the American public. Three alternative fire defense programs - Austere, Moderate, and Comprehensive - are suggested for consideration. The Comprehensive Program would be the most effective, but it would cost much more than the other two.

It is logical to begin the program at the Austere level, test its methods and approaches, develop equipment, and then later expand operations into the Moderate or the Comprehensive Program. Such an approach might show the optimum program to be a combination of elements from each. The Austere, Moderate, and Comprehensive Programs are flexible and can be compressed, interrelated, combined, or expanded as new

knowledge is developed or as any individual situation demands. It should be noted that the most effective measures require advance planning and ample time to install.

On the basis of preliminary calculations set forth in this Phase One report, data indicates the Austere Program could be fully implemented at a cost to the Federal Government of 41 million dollars, the Moderate Program at a cost of 268 million dollars, and the Comprehensive Program at a cost of 759 million dollars.

REQUIREMENTS FOR CONTINUING RESEARCH AND DEVELOPMENT

Equipment development, methods development, and feasibility studies must precede operational phases of the fire defense programs. Continuing research is needed to up-date and improve measures to reduce the threat of nuclear fires. Research and development are especially needed to:

1. Identify more fully the relations between weapons effects and the variables of weapon yields, height of burst, atmospheric attenuation, pulse shape, pulse duration, and fuel ignition characteristics.
2. Develop an effective classification for urban and rural fuels.

3. Determine more clearly how fires develop in urban areas.

4. Determine and define the characteristics of fire storms and conflagrations.

5. Improve input data for urban and rural fire-spread models.

6. Provide more information about how to protect shelters from fire.

III. SUMMARY OF RECOMMENDATIONS

Three alternative fire defense programs are described in this section; (1) Austere, (2) Moderate, and (3) Comprehensive. These comprise three different levels of preparedness depending upon the amount of effort and funds that can be devoted to the fire defense program. Implementing each program would require three phases covering a total of 5 or more years. These are an initial phase, an interim phase, and a full development phase. The initial phase very similar for all three programs, and provides the planning, methods development, studies, equipment development, and field tests necessary to launch the program. A complete program is evolved in the interim and full development phases of each alternative, but the various protective measures would be implemented only after development and field testing had proved them to be effective and feasible.

The authors recommend starting with the Austere Program. Such a program will make it possible to develop a modest additional life-saving capability within the existing OCD budget. This program can be expanded to a Moderate or Comprehensive Program as additional finances may become available, and as the national defense situation demands.

Figure 1 represents the comparative budget needs of the Austere, Moderate, and Comprehensive Programs.

FIGURE 1

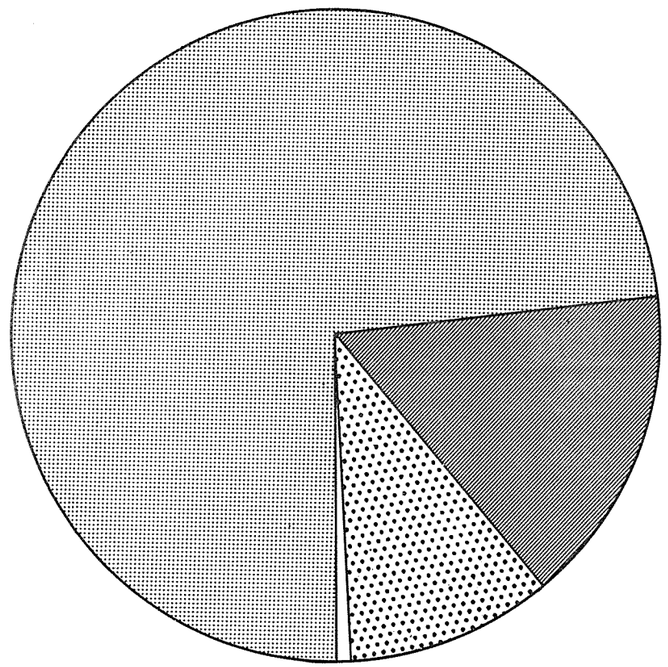
RELATIVE SIZE OF ALTERNATIVE FIRE PROGRAMS

(BASED ON COSTS TO OCD)

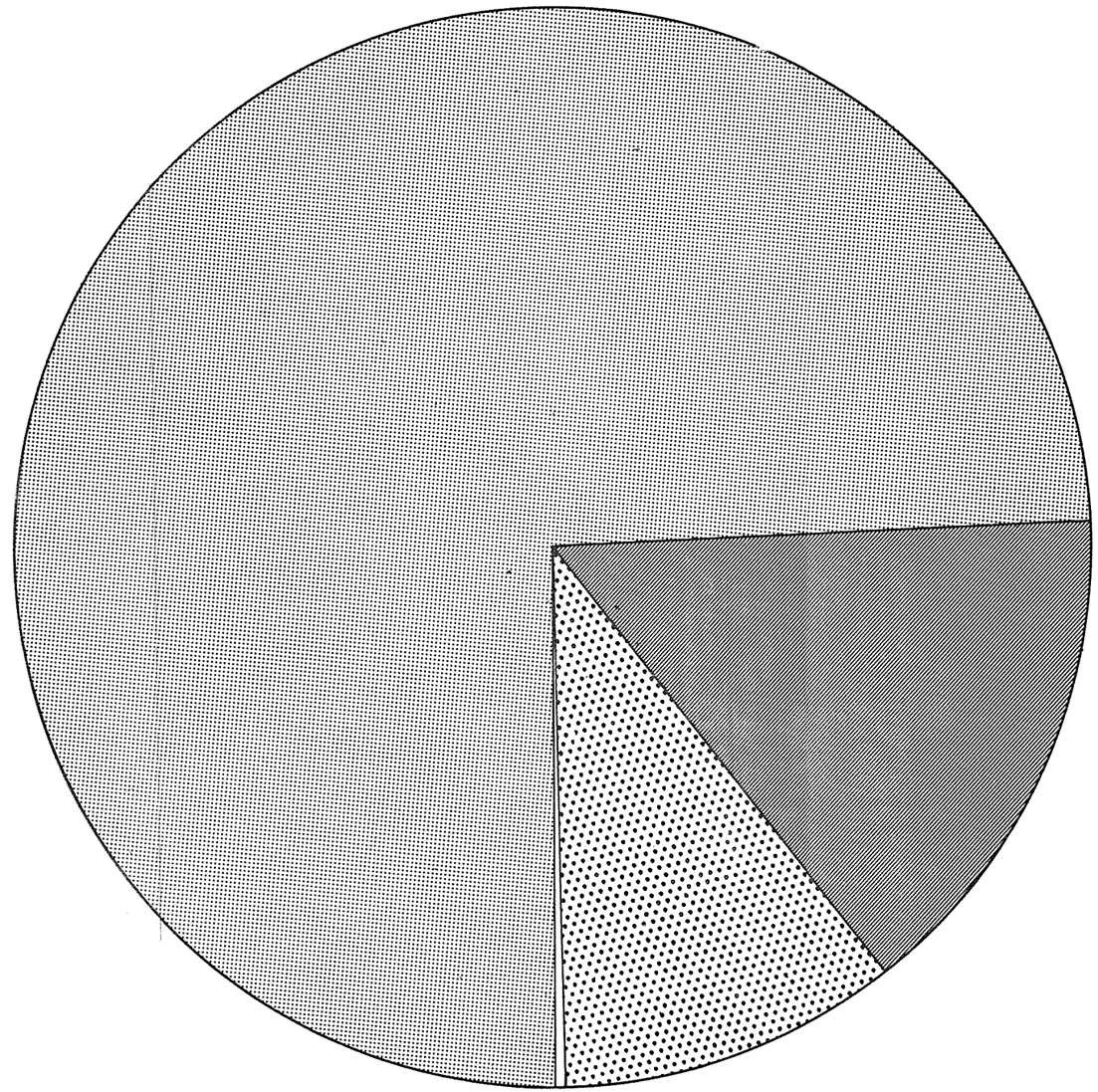
PERIOD

- INITIAL : FY 1966
- INTERIM : FY 1967-68
- FY 1969-70
- AFTER 1970

AUSTERE

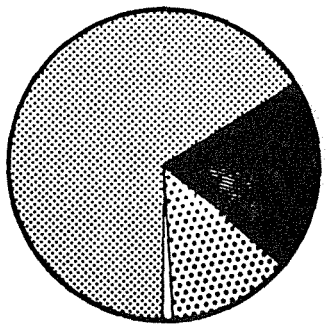


MODERATE



COMPREHENSIVE

AUSTERE
Fire Defense Program



THE AUSTERE FIRE DEFENSE PROGRAM (See Table 1)

Protection Measures. -- The Austere Program includes only the most basic and less-costly fire protection measures. Measures for citizen firefighting and fire prevention are included. TV and radio instruction kits would be prepared and kept in readiness at national networks and key locations in each state. These would be used to instruct citizens during times of increased international tension or during Fire Prevention Week drills. Simple window shielding to reduce thermal effects would be used. The Office of Civil Defense would stock supplies for shielding windows in approved shelter buildings as part of the shelter stocking program. Supplies for shielding windows in homes and places of business would be purchased and used by the citizens as the occasion demanded. Local Civil Defense officials would recommend when and how to use the shielding. Local CD and fire services personnel using OCD guidelines would inspect and rate shelters for fire vulnerability. Corrective action or alternative plans would be used to reduce the fire vulnerability of shelters. An infrared fire mapping system would be partially implemented to achieve an essential capability to meet a nuclear attack.

Support Plans. -- Analysis and support activities would be employed jointly by OCD, state and local governments, and responsible Federal agencies, and would include a nuclear fire analysis[1/] to provide a planning base for each community and to coordinate mutual aid preparations. Guides for community planning would ultimately reduce the fire vulnerability of cities. Studies would begin to develop plans for nationwide intelligence and communication systems.

Training. -- Training would prepare a minimum number of citizens and professionals to protect shelters and critical resources against nuclear fires. The national nuclear fire leadership training program would be 50 percent implemented by F. Y. 1970. The rural fire defense training program would be operational by F. Y. 1970.

(The Austere Program is discussed in detail in Section VII, pp. 113-120.)

1/ The nuclear fire analysis would be (1) an examination of the nuclear fire threat to each community, (2) an inventory of each community's capability to cope with the threat, and (3) an evaluation of the effectiveness of alternative protection measures.

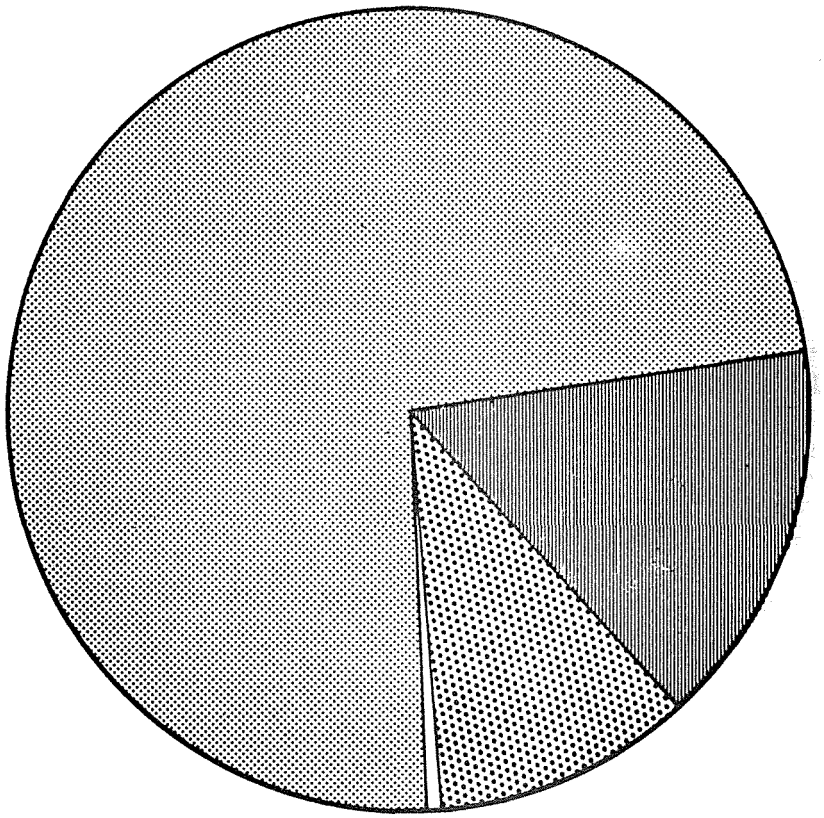
Table 1

AUSTERE OCD FIRE DEFENSE PROGRAM

	National Fire Coordination Study	Ref. Page	Initial Phase - F.Y. 1966	Interim Phase - F.Y.'s 1967-68	Full Development Phase After F.Y. 1968
PROTECTION MEASURES	Write statement of purpose & develop plan for a citizens' fire extinguishing & prevention program.	36	Develop TV & radio information kits for citizens' fire extinguishing & prevention program.	Distribute TV & radio information kits to National networks & states for use if attack is threatened.	Implement as needed.
	Make brief problem analysis, write statement of purpose & plan for developing effective & economical shielding for windows.	41	Design & develop effective economical shielding for windows including engineering feasibility studies.	Field test low-cost window shielding and implement 10 percent.	Achieve 25 percent of low-cost window shielding program by F. Y. 1970 and continue.
	Prepare statement of purpose for a program of inspection & rating of shelters according to their vulnerability to fire & relate to work done by Factory Mutual Research, Inc.	44	Develop a program with guidelines & instructions for inspecting & rating fire vulnerability of shelters.	Encourage state CD to inspect & rate fire vulnerability of currently approved shelters.	Continued operation.
		58	Develop field procedures, plans, & methods for mapping nuclear fires by infrared devices.	Complete testing & development of procedures for infrared fire mapping & develop 10 percent operational capability.	Achieve 25 percent operational capability for infrared mapping of nuclear fires by F. Y. 1970 & continue.
SUPPORT PLANS	Prepare guidelines & develop a nuclear fire analysis system & methods.	74	Field test nuclear fire analysis system & develop samples analyses for state & local guidance.	Achieve nuclear fire analysis for 25 percent of communities.	Achieve nuclear fire analysis for 50 percent of communities by F. Y. 1970 & continue.
	Prepare a National Fire Defense Plan.	78	Field test urban & rural fire defense plans & develop sample plans for local guidance.	Implement the National Fire Defense Plan.	Continued operation.
	Make brief problem analysis & prepare statement of purpose & outline the contents of guidelines for community planning to minimize urban fire spread.	83		Develop guidelines for community planning to minimize urban fire spread.	To be implemented by state & local governments on a continuing basis.
	Make brief problem analysis & write statement of purpose & action plan for studying the Nationwide Fire Intelligence System.	84		Develop scope and plans for a Nationwide Fire Intelligence System including full use of infrared.	Include in the National Fire Defense Plan.
	Make brief problem analysis & write statement of purpose & action plan for studying a Nationwide Fire Communications System.	86			Develop scope and plans for a Nationwide Fire Communications System.
TRAINING	Develop an outline of course content & recommend how to activate National Nuclear Fire leadership training.	96	Develop a program for National Nuclear Fire leadership training.	Achieve 25 percent activation of National Nuclear Fire leadership training program.	Achieve 50 percent activation of National Nuclear Fire leadership training program by F. Y. 1970 & continue.
		104	Continue training in rural areas for fire defense.	Make the rural fire defense program partially operational.	Rural fire defense training program operational by F. Y. 1970 and continuing.

MODERATE

Fire Defense Program



THE MODERATE FIRE DEFENSE PROGRAM (See Table 2)

The Moderate Program compresses the time for implementation so that greater readiness is achieved by 1970 than under the Austere Program.

Protection Measures. -- The Moderate Fire Program employs the same basic citizens' firefighting and prevention measures as the Austere Program. The citizens' TV and radio information kits are the same. The plan to shield windows from nuclear thermal effects differs from that in the Austere Program in that shielding would be designed to partially withstand maximum blast pressure of 5 p. s. i. from multiple nuclear detonations; this would provide some protection from repetitive thermal pulses to important buildings capable of withstanding 5-10 p. s. i. blast pressures. Shelter inspection, rating, and protection is the same as in the Austere Program. Preparations for infrared mapping of nuclear fires would achieve essential capabilities by F. Y. 1970.

Support Plans. -- Professional fire staff leadership would be installed at the national level during the interim period to guide the technical phases of the approved program. The Moderate Program includes special studies to develop plans for fire intelligence and communication systems and to determine the most effective use of aerial fire retardants to protect shelters.

Training. -- Citizens and professionals would be trained to take essential fire leadership, rescue, and control actions during and after a nuclear attack. A technical staff support center would be established to help convert research findings to operational action.

(The Moderate Program is discussed in detail in Section VII, pp. 121-127.)

Table 2

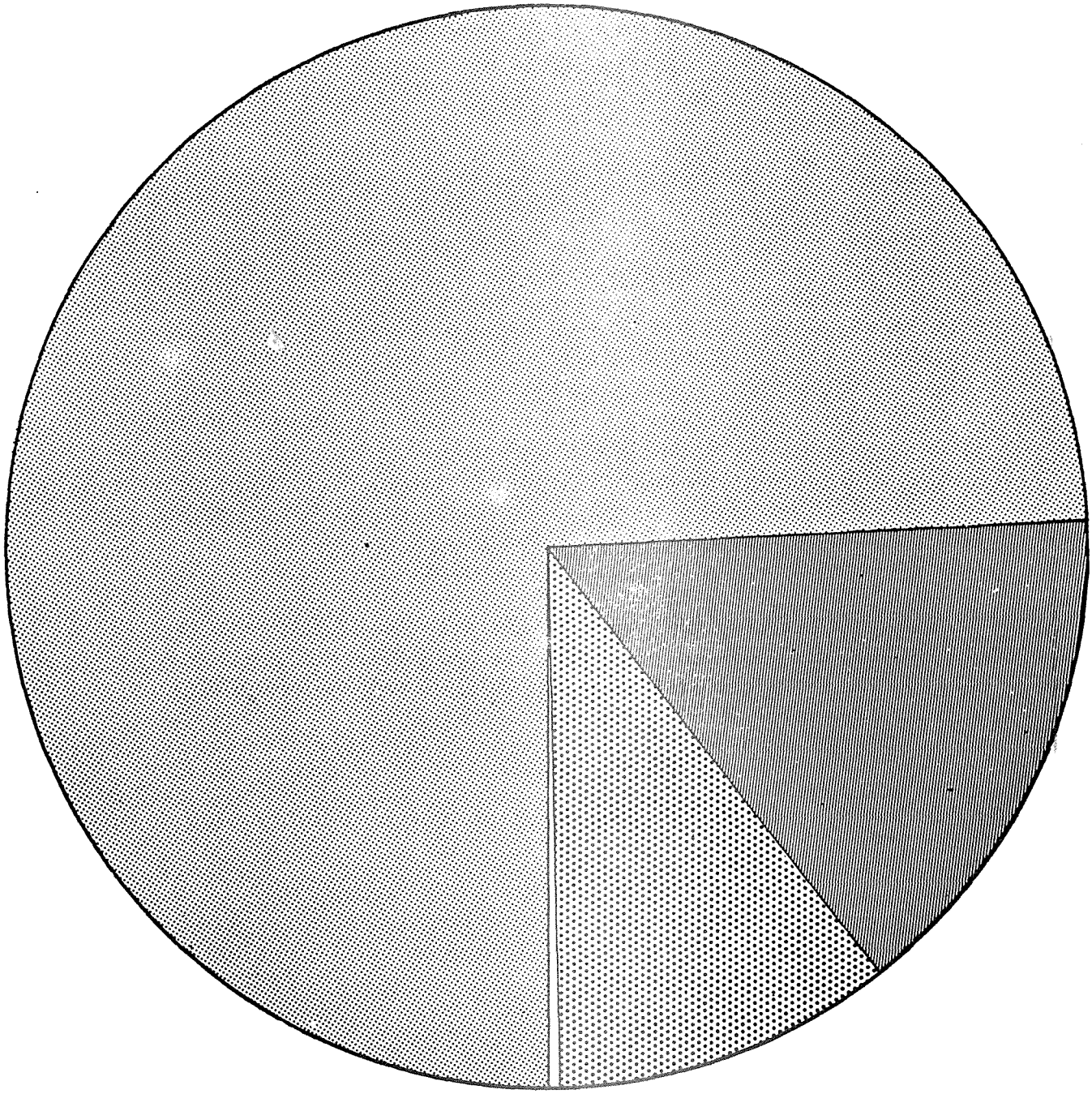
MODERATE OCD FIRE DEFENSE PROGRAM

	National Fire Coordination Study	Ref. Page	Initial Phase - F.Y. 1966	Interim Phase - F.Y.'s 1967-68	Full Development Phase After F.Y. 1968
PROTECTION MEASURES	(**Write statement of purpose & development plan for a citizens' fire extinguishing and prevention program.	36	**Develop TV & radio information kits for citizens' fire extinguishing & prevention program.	**Distribute TV & radio information kits to National networks & states for use if attack threatens.	**Implement as needed.
	(**Make brief problem analysis & prepare statement of purpose & plan for developing effective & economical shielding for windows.	41	**Design & develop effective & economical shielding for windows including engineering feasibility studies.	Field test tailor-made window shielding & implement 10 percent of the shielding program.	Achieve 25 percent of the tailor-made window shielding program by F.Y. 1970 and continue.
	(**Prepare statement of purpose for a program of inspection & rating of shelters according to their vulnerability to fire & relate to work being done by Factory Mutual Research, Inc.	44	**Develop a program with guidelines & instructions for inspecting & rating fire vulnerability of shelters.	**Encourage state CD to inspect & rate fire vulnerability of shelters.	**Continued operation.
		58	**Develop field procedures, plans, & methods for mapping nuclear fires by infrared devices.	**Expand infrared capabilities to 40 percent of program needed for nuclear fires.	**Complete operational capability for infrared mapping of nuclear fires by F.Y. 1970.
	Make brief problem analysis & write statement of purpose & plan for determining the effectiveness of aerial fire retardants in protecting shelters from fire.	62		*Determine the effectiveness of aerial fire retardants in protecting shelters from fire.	Include findings in Fire Defense Plans.
SUPPORT PLANS	(**Prepare guidelines & methods for a Nationwide Nuclear Fire Analysis System.	74	**Field test Nuclear Fire Analysis System & develop samples for state & local guidance.	Achieve 50 percent implementation of the Nuclear Fire Analysis System.	Fully implement the Nuclear Fire Analysis System by F.Y. 1970 & continue.
	(**Prepare a National Fire Defense Plan.	79	**Field test fire defense plans & develop samples for local guidance.	**Implement the National Fire Defense Plan.	Continued operation.
	(**Make brief problem analysis & prepare statement of purpose & outline of contents of guidelines for community planning to minimize urban fire spread.	83		**Develop guidelines for community planning to minimize urban fire spread.	**To be implemented by state & local governments.
		90		Provide professional fire leadership, plus clerical help, to achieve technical phases of the approved fire program.	Continued operation.
	(**Make brief problem analysis & write statement of purpose & plan for studying a Nationwide Fire Intelligence System.	84	Develop scope and plans for a Nationwide Fire Intelligence System including full infrared use.	Include in National Fire Defense Plan.	Continued implementation.
	(**Make brief problem analysis & write statement of purpose and plan for studying a Nationwide Fire Communications System.	86		Develop scope and plans for a Nationwide Fire Communications System.	Include in National Fire Defense Plan.
TRAINING	(**Develop an outline of course content & recommend how to implement National Nuclear Fire leadership training.	96	**Develop a program for National Nuclear Fire Leadership Training.	Achieve 50 percent implementation of a National Nuclear Fire Leadership training program.	Fully implement the approved National Nuclear Fire leadership training program by F.Y. 1970 & continue.
		104	**Continue fire defense training in rural areas.	Rural fire defense training program operational.	Program continued.
	Recommend how to implement a program for fire service use in training fire defense support firemen. Tie in with Okla. State Training package.	101	Develop a program for fire service use of Fire Defense Support firemen.	Program implemented by fire services.	Continued operation.
	Write statement of purpose & describe the scope, content, staff, & procedures for a National Fire Technical Staff Support Center.	93			Install the Fire Technical Staff Support Center by F. Y. 1970.

** Includes same item, time-phasing, and scope as the Austere Program.

COMPREHENSIVE

Fire Defense Program



THE COMPREHENSIVE FIRE DEFENSE PROGRAM (See Table 3)

The Comprehensive Program would use today's nuclear fire knowledge in an effort to remove all possible survivors from fire risk in the event of a nuclear attack.

Protection Measures. -- A complete state of readiness would be achieved by F. Y. 1970 in all except the smoke generator measures which would be 25 percent complete. The central thermal energy reduction measure would be smoke generation or a similar method. Window shielding and fire-retardant sprays would be supplemental measures.

Support Plans. -- Nuclear fire analyses would be conducted for each community or planning area, including a computer program tied in with existing damage assessment capability. Organized fire control and rescue activities would be supported by comprehensive intelligence and communication systems. Professional fire staff leadership would be fully developed by F. Y. 1970.

Training. -- Training programs would provide the full complement of qualified citizens and professionals needed for the nuclear fire threat. A technical staff support center would be created to convert fire research findings to operational action more rapidly and thoroughly.

(The Comprehensive Program is discussed in detail in Section VII, pp. 127 - 133 .)

Table 3

COMPREHENSIVE OCD FIRE DEFENSE PROGRAM

	National Fire Coordination Study	Ref. Page	Initial Phase - F. Y. 1966	Interim Phase - F. Y.'s 1967-68	Full Development Phase After F. Y. 1968
PROTECTION MEASURES	**Write statement of purpose & develop plan for a citizens' fire extinguishing & prevention program.	36	**Develop TV & radio information kits for citizens' fire extinguishing & prevention programs.	**Distribute TV & radio information kits to National networks & states for use if attack threatens.	**Implement as needed.
	Make brief problem analysis & write statement of purpose & plan for effectively treating combustible furnishings in homes.	38		Develop an effective way to treat combustible furnishings in homes.	Implemented by the householder.
		40	Begin field testing smoke generator system. Tie in with research already underway.	Complete field tests of the smoke generator system & achieve 10 percent implementation of the program.	Achieve 25 percent implementation of the smoke generation program by F. Y. 1970 and continue.
	**Make brief problem analysis & write statement of purpose & plan for developing effective & economical shielding for windows.	41	** Design & develop effective & economical shielding for windows including engineering feasibility studies.	Implement a window shielding program if it proves to be a necessary & feasible support to the smoke generator program.	Continue as needed.
	**Prepare statement of purpose for a program of inspection & rating of shelters according to their vulnerability to fire & relate to work being done by Factory Mutual Research, Inc.	44	**Develop a program with guidelines & instructions for inspecting & rating fire vulnerability of shelters.	** Encourage state CD to inspect & rate the fire vulnerability of shelters.	**Continued operation.
		58	**Develop field procedures, plans, & methods for mapping nuclear fires by infrared devices.	**Expand infrared mapping procedures to 40 percent of the program needed for nuclear fires.	**Complete operational capability for infrared mapping of nuclear fires by F. Y. 1970.
	**Make brief problem analysis & write statement of purpose & plan for determining the effectiveness of aerial fire retardants in protecting shelters from fire.	61		**Determine the effectiveness of aerial fire retardants in protecting shelters from fire.	**Include findings in Fire Defense Plan.
	Make brief problem analysis & write statement of purpose & plan for special equipment needs to suppress nuclear fires.	64		Determine special equipment needs for suppressing nuclear fires.	Develop & test needed equipment.
SUPPORT PLANS	** Prepare guidelines & recommend methods for a Nationwide Nuclear Fire Analysis System.	74	**Field test Nuclear Fire Analysis System & develop samples for state & local guidance.	**Achieve 50 percent implementation of the Nuclear Fire Analysis System.	**Fully implement the Nuclear Fire Analysis System by F. Y. 1970 & continue.
	**Prepare a National Fire Defense Plan.	79	**Field test fire defense plans & develop samples for local guidance.	**Implement the National Fire Defense Plan.	Continued operation.
	**Make brief problem analysis, prepare statement of purpose & outline of contents for guidelines in community planning to minimize urban fire spread.	83	Develop guidelines for community planning to minimize urban fire spread.	To be implemented by state & local governments.	Continued operation.
		90	Provide professional staff leadership, with clerical help, to achieve technical phases of the approved fire program.	Continuing	Continued operation.
	Prepare statements of purpose & plans for developing a fire service radio operating procedure handbook & fire terminology hdbk.	88		Prepare a standard fire service radio operating procedures handbook.	Arrange a standard fire service terminology for the United States.
	** Make brief problem analysis & write statement of purpose & plan for studying a Nationwide Fire Intelligence System.	84	**Develop scope and plans for a Nationwide Fire Intelligence System including full infrared use.	**Include in the National Fire Defense Plan.	**Continued implementation.
	** Make brief problem analysis & write statement of purpose & plan for studying a Nationwide Fire Communications System.	86		** Develop scope and plans for a Nationwide Fire Communications System.	** Include in National Fire Defense Plan.
TRAINING	**Develop an outline of course content & recommend how to implement National Nuclear Fire leadership training.	96	**Develop a program for National Nuclear Fire leadership training.	**Achieve 50 percent implementation of the National Nuclear Fire leadership training program.	**Fully implement the approved National Nuclear Fire leadership program by F. Y. 1970.
		98	Develop guidelines & samples for state & local Nuclear Fire leadership training.	Training to be conducted by state & local CD & fire services.	Continued operation.
		104	** Continue fire defense training in rural areas.	** Rural fire defense training program operational.	Program continued.
	**Recommend how to implement a program for fire service use of Fire Defense Support firemen. Tie in with Oklahoma State Training Package.	101	** Develop a program for fire service use of Fire Defense Support firemen.	Program implemented by the fire services.	Continued operation.
	**Write statement of purpose & describe the scope, content, staff, & procedures for a Nat'l. Fire Technical Staff Support Center.	93		Install the Fire Technical Staff Support Center.	Continued operation.

** Includes same item, scope, and time-phasing as the Moderate Program.

IV. THE NUCLEAR FIRE PROBLEM

As a basis for this report, the nuclear fire problem has been analyzed in terms of: (1) lives exposed to fire risk, (2) the relative significance of blast, fallout, and fire, and (3) land area burned in the United States. It is possible to expand the analysis to include the impact of nuclear fire on other factors that influence the ability of the United States to recover from a nuclear attack. Potential damage to resources and industrial capabilities are examples.

The nuclear fire problem, as analyzed for the purpose of this report, depicts the situation that would result if no extraordinary preventative or organized fire suppression measures were taken in preparation for a nuclear attack. It is assumed that normal peacetime fire control activities would be in effect. Recommendations made in Section VII of this report contain procedures that would reduce the threat of nuclear fires to acceptable limits.

In determining the nature and extent of the nuclear fire threat, detailed blast, fallout, and fire-hazard assessments were made for three large cities, and fire spread was computed for the total land area of the United States. Pertinent research findings were summarized and used to analyze the fire hazard. Calculations were based on hypothetical light, medium, and

heavy attacks, involving both missile and aircraft-delivered weapons in a thermonuclear assault upon the Military, civilian, and economic resources of the country. The several damage assessments were based on the meteorological conditions of 24 August 1964, except average-bad fire conditions for August were used in computing the fire spread to the total land area of the United States. The possible development of mass fires (fire storms and conflagrations) has not been assessed.

ASSESSMENT MODELS

Currently, there are no comprehensive assessment models which accommodate the effects of blast, fallout, and fire, simultaneously. Separate models were used to calculate the effects of each. The procedure is to assess fire spread after computing blast and fallout damage. These models were used in the study:

Blast Model. -- Manual computations were made. Data derived by the Dikewood Corporation were used. These data were developed for OCD use in the report, "Prediction of Urban Casualties from the Immediate Effects of a Nuclear Attack", April 1963, classified "Confidential".

Fallout Model. -- The Weapons-System Evaluation Group Model (WSEG RM 10) was used manually to derive data. This model has been used in other OCD studies.

Urban Fire Spread Model. -- Manual computations were made utilizing an interim fire model developed by Illinois Institute of Technology Research Institute. This model is based upon an event-by-event representation of each and all fire occurrences. It is admirably suited to assess the effectiveness of fire control countermeasures. The model has the potential to be applied to the data bank collection problem to make better use of information currently on tapes, and to reduce the proportion of additional field data needed.

Rural Fire Spread Model. -- Manual computations were made utilizing ignition and spread data developed by the Forest Service for fire-susceptible areas of the U. S. for monthly "average-bad" fire weather conditions. A parallel computer run was made using the Flame 1 fire spread simulator model. The results of this run are available in the National Fire Coordination Study file, but they were not available in time to use in this Phase One report.

The fire models used have a potential for application in the subject areas of problem analysis, planning, program decisions, and operations during an emergency. The IIT Research Institute model--wnen fully developed--and Flame I, could provide a framework for fire-data storage and analysis for some time to come. The most significant immediate future improvements will likely come from improvement of input data for the models, i. e., better knowledge of urban fire spread, and more refined weather data for rural fire spread.

EFFECTS OF ATTACK

Calculation of the various effects for each attack postulated in this study on the population of three cities shows that a very high proportion of a poorly-sheltered population would become fatalities from the direct blast and fallout effects of attack. Under these conditions few people would be alive in areas where ignitions occur from nuclear thermal flash. Fires would threaten a lesser, but nonetheless significant, number of human lives than would be the case if the population is well-sheltered.

Under conditions where the population is well sheltered the lives of many people who would otherwise die from direct effects of blast and fallout will be saved. Some of these people will be in areas where ignition from thermal flash and subsequent fire spread will present a threat.

The extent of fire ignition and spread throughout the total land area of the United States has been computed. Results are shown in Figure 2 for average-bad fire conditions for the month of August. Approximately 10 percent of the land area may be involved in rural and wildland fires in this extreme case. In less fire-susceptible conditions of vegetation and weather, the burned areas, would be less, but would still present a significant problem, especially in view of the obvious likelihood of accompanying fallout which would add to the problems of fire control.

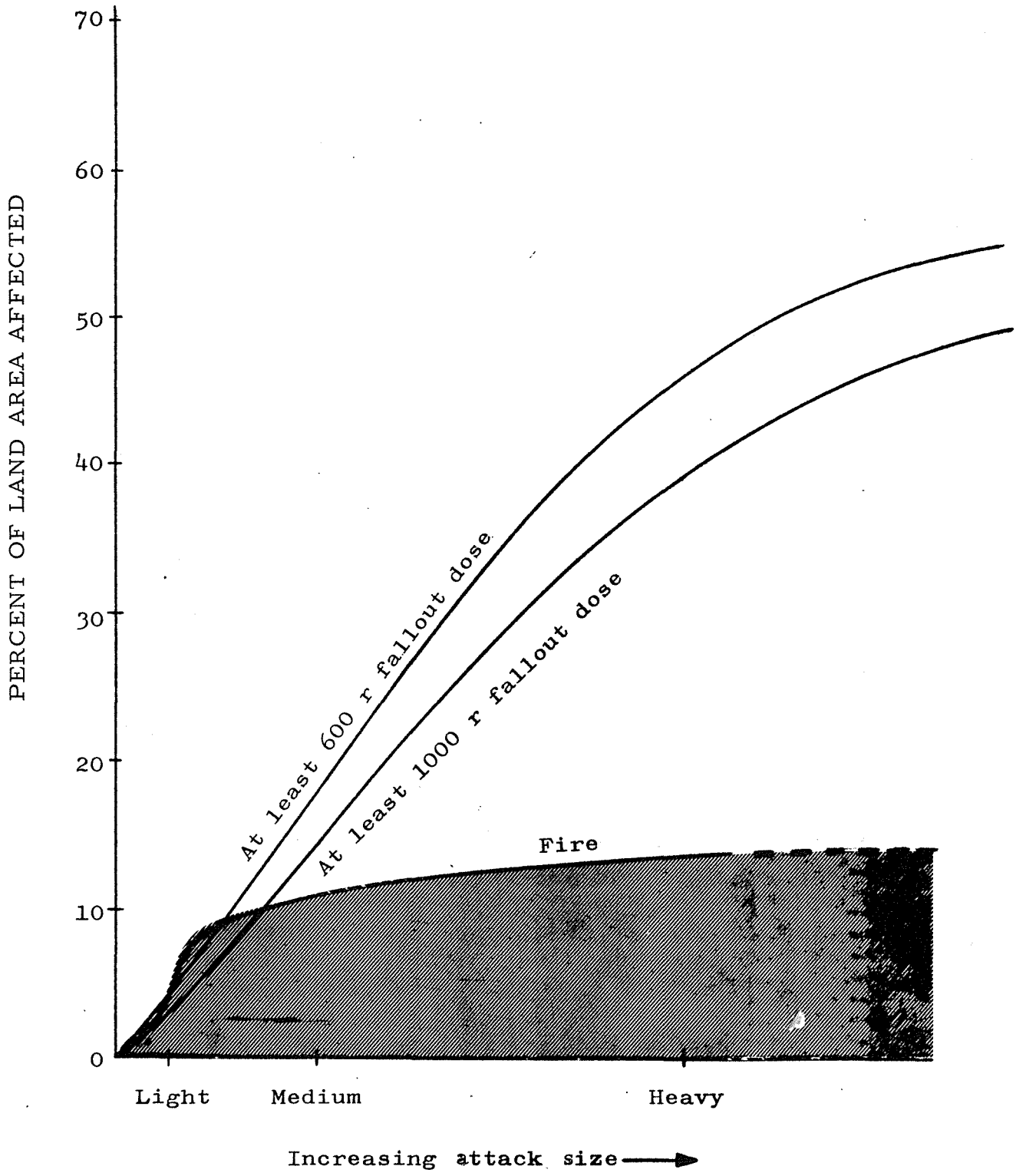


FIGURE 2. Effects of nuclear attack on total land area of the United States.

SUMMARY [1/]

1. Nuclear fire is a lesser threat to lives than blast and fallout, if the population is in residence. This is because the overwhelming effects of blast and fallout leave fewer persons alive to be threatened by fire.

2. Nuclear fire is a significant hazard for a well-sheltered population. More people are alive in areas threatened by fire, hence more are exposed to fire risk.

3. Nuclear fire will become proportionally more serious as progress is made in protecting lives from blast and fallout.

4. Nuclear fires burning in rural areas will be a serious problem under certain weather conditions. Approximately 10 percent of the land area of the United States could be burned.

1/ The findings are for the attack simulated in this report. It is probable to conceive of attack patterns where both blast and fallout are minimal, and fire would represent the maximum hazard. However, the attacks used in this analysis are those considered most probable by OCD.

V. EXISTING FIRE DEFENSE CAPABILITIES

In determining what the scope and content of a national fire defense program should be, it is necessary to examine existing fire defense capabilities in the United States and relate these to the requirements that might result from a nuclear attack.

PRE-EMERGENCY READINESS

Fire capabilities were examined during Phase One by studying existing mutual aid and command situations in the states of Massachusetts, California, Michigan, Oregon, and the Washington, D. C., metropolitan area. These studies covered existing fire control capabilities, degree of preparedness for disaster situations, degree of understanding of the nuclear fire problem, and the extent of involvement of fire services in Civil Defense planning. The five areas studied might not be truly representative of the overall situation in the United States, but they are a sizable sample. Twenty-four conclusions were drawn from these studies. The most significant of these are:

1. The magnitude and complexity of the nuclear fire threat is not generally understood by fire service personnel at the local level.
2. Public service personnel who will face the problem together should train together.
3. It is often not clear at the local level who would be in command of the tactical fire situation in a nuclear emergency.
4. A nuclear disaster problem area could include several political jurisdictions.
5. Acute communication problems may exist for a time following a nuclear attack.
6. The most effective fire services do the best job of pre-emergency planning.
7. Fire services are providing excellent tactical training for firemen. Command training at the national, state, and local levels is a high-priority need.
8. Fire manpower and equipment are not always in balance. Some fire companies are not able to fully man the equipment available to them.
9. Pre-emergency fire planning should include ignition point reduction, zoning, community planning to prevent fire spread, and treatment of rural fuels that create a fire threat to urban areas.

CAPABILITY DURING FIRE EMERGENCIES

Four large fires were studied by the National Fire Coordination Study Staff to determine how existing fire control organizations functioned in an emergency, how adequate their resources and manpower were, and what, if any, actions observed could be used to prevent or control fires associated with a nuclear attack. While these four fires do not represent the full range of fire potentials in a nuclear situation, they exemplified many problems common to large fires. The fires studied were:

Deadwood Fire, South Dakota, September 1959

Nevada Fires, Nevada, August 1964

Park Headquarters Fire, South Dakota, September 1964

Santa Rosa Fires, California, September 1964

The most significant conclusions to be drawn from these studies are:

1. Existing pre-emergency fire planning would generally not be adequate for effective action on nuclear fires.
2. Better coordination of effort between fire services and civil defense organizations would enhance effectiveness in some localities.
3. The sheltered populace is itself a valuable fire control resource, and effective use can be made of them.

4. Communications results were inadequate on all fires.
5. Equipment shortages were experienced on all fires.
6. The occurrence of multiple fires greatly compound the problem of utilizing men and equipment effectively.
7. Existing strategic and tactical intelligence systems and resource locator and dispatching systems would generally be inadequate for a nuclear fire.
8. Frequent joint involvement of fire services, other mutual aid sources, and Civil Defense coordinators in minor emergencies would strengthen ability to act effectively in severe emergencies.
9. Establishment of a central command makes large fire suppression efforts more effective.

NUCLEAR vs. PEACETIME FIRE CONTROL REQUIREMENTS

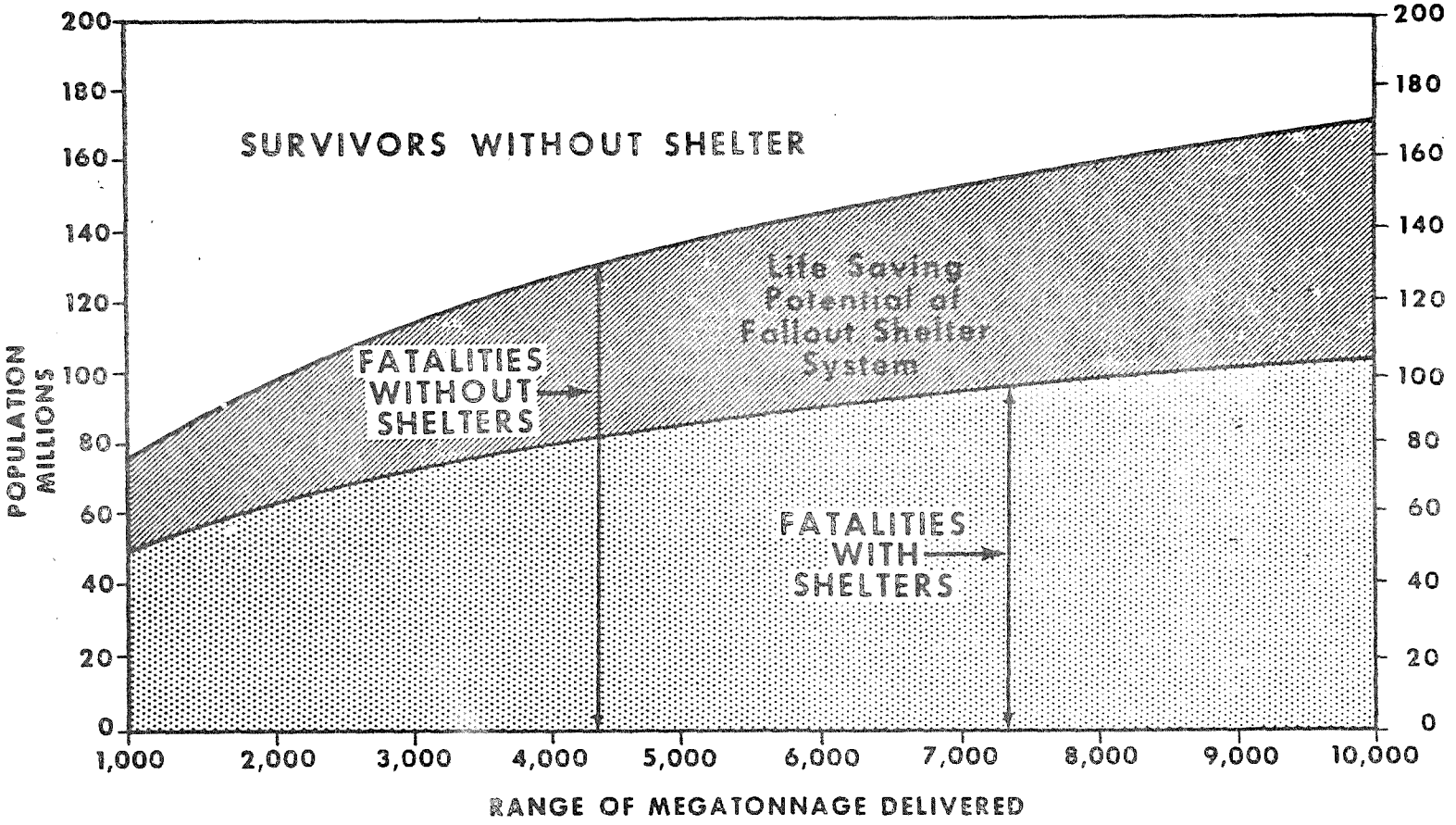
Organization efforts to control fires in the United States have historically been done on a community-by-community basis. This evolvement has produced strong, usually autonomous capability in many communities. Combined with advanced technology, this capability is our Nation's most fundamental strength for fire defense in nuclear war; since it is these firemen, plus the civilian populace, that must face the fire threat independently

until it is possible to provide aid to stricken communities. Fire prevention activities and arrangements for mutual aid and command between communities are usually patterned to cope with such fire disasters as the community has typically experienced. "Fire disasters typically experienced" seems a logical guideline for maintaining current operating capability for urban and rural jurisdictions. But the fire problem that could develop from a nuclear attack is so much worse than the "Fire disaster typically experienced" that the existing fire protection capability in the United States would be quickly overwhelmed. Thus, the action required to assure that fire defense capability is adequate for the nuclear fire threat includes utilization of latest technological advances within existing fire capabilities, plus flexible arrangements to cope with the severe burden of fires in the nuclear attack aftermath.

VI. POTENTIAL ELEMENTS OF A FIRE DEFENSE PROGRAM

Results of the analytical studies of the nuclear fire problem described above have demonstrated that the fire threat inherent in a nuclear attack presents a significant hazard to the population and resources of the United States, both in cities and rural areas. Moreover, the fire threat assumes greater significance for a sheltered population. Fire defense requires increasing attention as Civil Defense copes more successfully with the fallout and blast impact generated in a nuclear attack.

Fallout shelters are the basic measure necessary for saving lives after a nuclear attack. The life-saving potential of the fire defense program is primarily for survivors in fallout shelters after the blast. The life-saving potential of the fallout shelter program is indicated in Figure 3, extracted from the pamphlet "Fallout Shelter Effectiveness, The U. S. Civil Defense Program". This figure shows the shelter program to have a capability of saving about 56,000,000 persons from death by blast and fallout in the case of a 7,000-megaton nuclear attack.



In event of attacks against military targets alone, total fatalities would be reduced and life saving potential of shelters would be increased.

SOURCE: Composite of damage assessment studies by Department of Defense

FIGURE 3 Life saving potential of fallout shelter system in attacks against Military - urban - industrial targets (From OCD publication "Fallout Shelter Effectiveness, the U. S. Civil Defense Program", July 1963)

A national program of fire defense is needed to deal with nuclear fires. Such a program should be an integral part of the Civil Defense planning and operations to cope with nuclear disasters or other large catastrophes. Studies made during Phase One yielded protection measures, support plans, training, and research information that, when integrated into a balanced program, have a potential to reduce the nuclear fire threat.

PROTECTION MEASURES

Protection measures having immediate application include ways to reduce the numbers of ignition points, reduce thermal effects, reduce vulnerability of fallout shelters to fire; and to apply selective, organized fire suppression and rescue efforts. City planning to minimize urban fire spread and fuel reduction measures in rural areas have a long-range potential for reducing the fire threat.

Reducing the Number of Ignition Points

The process of ignition from thermal energy is governed by the quantity and rate of heat buildup in the irradiated surface as diminished by the quantity and rate of heat dissipation through re-radiation, through conduction to underlying layers, and to a lesser extent through convection. The magnitude, rate of

emission, and duration of the thermal pulse delivered by a nuclear weapon are important factors. Many variables affect ignition following a nuclear detonation, but the fire defense planner can assume that thin, light-combustible materials (kindling fuels) play the principal ignition role, and that such materials, if dry, will probably be ignited if they are exposed directly to the thermal pulse. Thus, measures to reduce ignition points center around cleanup campaigns, citizen actions to place kindling fuel items out of line of sight from windows and other openings, fireproofing combustibles, and covering combustibles with fireproof sheets.

Citizens' Fire Extinguishing and Prevention Program

A citizens' fire extinguishing and prevention program provides an effective basis for implementing other protection measures. The basic component would be a TV and radio information kit containing film strips, recordings, and instructions to householders. The instructions in the kit would apply nationwide, but some additional information would be necessary to inform the people about the details of the local plan for their community. The kits would be available to national radio and TV networks, and to Fire Service and Civil Defense officials. These would be shown and demonstrated on television and broadcast on radio

stations during periods of extreme international tension. They could also be highlighted during Fire Prevention Week. They would supplement the information normally distributed by Civil Defense pamphlets and training courses.

Instructions to householders would depend, in part, upon the state of readiness of other Civil Defense programs. For example, if preparatory measures have made opaque window coverings (described later) available to householders, the television and radio instructions should show how and when to install them. All programs should contain the simple fire prevention steps each householder should take before seeking shelter. For example, householders could be instructed to close venetian blinds, move combustible furnishings to inner rooms, clean up flammable trash, turn off electricity, and extinguish pilot flames.

The citizens' TV and radio kit containing information on extinguishing and preventing fire could be prepared by OCD at low cost, including instructions for its use by national networks and suggestions for expanding the contents to fit the peculiarities of local plans. This measure could be implemented immediately with little impact on state and local governments or the public.

The OCD pamphlets Firefighting for Householders and Home Protection Exercises contain valuable instructions that would supplement citizens' TV and radio fire prevention and suppression program.

Treating Combustible Furnishings with Fire Retardant Chemicals, or Covering them with Fire Retardant Sheets

This measure has a potential to reduce the number of ignition points. It will be most effective if a suitable retardant can be developed in pressurized spray cans and made available in stores for purchase and use by citizens. The product should not damage furnishings or detract from their appearance.

Covering combustibles with fire retardant sheets would have much the same effect as treating furnishings with fire retardant chemicals. The chemical retardants in spray cans would be more convenient for the householder to use, and the likelihood of his having it available for use would be greater. The fire retardant sheets might prove to be more feasible for covering furnishings in large rooms within range of the thermal pulse.

Equipment development and feasibility studies must be made before either the fire retardant chemical or fire retardant sheet protection measures can be used. These studies would include a survey of products currently available commercially and adaptation or further development as needed.

The investment by OCD would be small and generally limited to development of the product and instructions for use to prevent fires following nuclear attack. Most of the cost would be met by the householder who would purchase and use the product.

Reducing Thermal Effects

Thermal energy is emitted during the first few seconds following a nuclear detonation and travels through space at the speed of light. Blast energy radiates out from the detonation at little more than the speed of sound. The fission products and induced radioactive materials created in the detonation are carried upward in the rising fireball as it cools into a cloud. The time of arrival of these three principal casualty agents at a point 5 - 10 miles from the detonation of a surface burst of a 1-10 megaton warhead is approximately in this order: the heat pulse arrives immediately and lasts 8 - 10 seconds; the blast wave arrives in about 30 seconds and lasts 7 seconds; the fallout arrives in about 1/2 hour and remains for several days. The thermal energy is radiated in (extremely short) wave-lengths roughly similar to that of sunlight; thus, it is possible to attenuate this energy in the atmosphere through which it must pass by using smoke or fog. Heat-reflecting opaque materials on windows would be effective in preventing the weapons' thermal energy from "shining" upon

window-shielding measures would be effective for the initial thermal pulse, but would be subject to damage from the subsequent blast wave. Thus, their effectiveness would be reduced if multiple detonations occurred. Attenuation of atmospheric thermal transmissivity by smoke screening and covering windows to shield combustible furnishings from the thermal flash are the principal measures considered for reducing thermal effects.

Smoke Screening

Smoke generation seems to be the most obvious measure to reduce thermal effects. An experimental smoke generation system is presently being developed by the Office of Civil Defense and is scheduled for completion in time for field testing by October of 1965. The smoke generator system should be field tested in a large uninhabited area. Side effects should be examined, such as confusion created by the smoke in evacuation and rescue efforts, and problems created for air and ground intelligence.

The smoke system would consist of a grid of generators. Spacing would depend on the anticipated amount of warning time and expected local windspeeds. Generators would produce enough smoke to screen the area in the anticipated response time. Additional smoke would be generated at intervals to maintain the screen for the duration of the attack.

The system would be controlled from a central source. The potential of achieving full implementation with this control would be much greater than for those protection measures to be effected by the citizens. The costs and logistics of the smoke generation measure suggest its installation be a long-term venture. If field studies show the measure to be feasible, it could be provided first for selected cities especially in areas where clear weather patterns occur much of the time.

Smoke generation would be an expensive measure. The costs of an effective system are estimated to be $150,000 per square mile. If it were assumed that the Office of Civil Defense would pay 50 percent of these costs on a sharing basis, then the OCD investment to fully implement the system to protect an urban population of 130 million people, would be approximately $750 million.

Window-Shielding

Window-shielding measures could vary in quality from very modest "do-it-yourself" shielding to more sophisticated shielding capable of withstanding blast pressures of 5 p.s.i. Combinations of measures of different quality could be used. For example, a modest "do-it-yourself" program could be arranged for the householder, with a more sophisticated program used in buildings which housed the shelters. Adjustable opaque window coverings could be designed,

manufactured, stock-piled, and distributed during times of tension for use by householders. Any window-shielding measure, or combination of measures, will require study of available products, development of equipment, and adequate testing before the measures can be put into effect.

The most modest window shielding to be considered was household aluminum foil taped to windows in all buildings. Efficiency of this measure in preventing ignitions is estimated to be 35 percent for a light attack because some buildings would be unoccupied and some citizens will not install the foil. Efficiency is reduced to 30 percent for a heavy attack to allow for damage by blast waves from multiple detonations. The investment required by OCD to implement a modest "do-it-yourself" window-shielding program is approximately 34 million dollars if OCD pays the costs of materials stocked to shield windows in shelter buildings and conducts an informational program for citizens.

Opaque window-shielding could be tailor-made for easy fastening to the interior of home windows. This material could be produced in a few adjustable sizes to fit most windows. Especially-designed screening could be used to cover large windows. It might be developed to partially withstand blast pressures up to 5 p.s.i. which would provide additional protection in buildings surviving multiple blast waves.

An investment by OCD estimated at 260 million dollars would be required to purchase and stock these tailor-made window shields for shelter buildings, and conduct informational programs to acquaint householders with their use.

Additional lives can be protected from fire risk by the use of window-shielding materials designed to resist blast effects in the 5 p.s.i. range. This shielding would sustain light or negligible damage from flying glass as the windowpane is destroyed in the blast wave. Such a shield might be constructed in the form of a series of shutters anchored and pivoted at the sides of the window frame. The advantage of the system over the tailored single-sheet system described above is its ability to shield thermal radiation and to respond quickly to the shock-wave front in allowing the wave to pass with a minimum of resistance. Costs for this window-shielding and combinations of these and other protection measures are given on Table 14, Page 145.

Implementing the blast-resistant, shutter-type measure would be costly and difficult. Its use should probably be limited to important buildings that are capable of withstanding 5-10 p.s.i. blast pressures. The tailor-made and improvised window-shielding measures seem feasible. The tailor-made shielding is effective

under conditions of multiple detonation, whereas the improvised shielding is most effective in a light attack since it cannot provide significant protection after the initial detonation. Equipment development and feasibility studies might disclose ways of reducing costs while subsequently maintaining an acceptable range of effectiveness. If, after further study, the smoke generator idea proves feasible, then the need for aluminum window coverings will be lessened. In areas where the generators are installed, the aluminum window covers would become auxiliary equipment.

Reducing the Vulnerability of Fallout Shelters to Fire

The nature and extent of the nuclear fire threat indicates that protecting the populace in fallout shelters from fire is necessary. The life-saving potential of such shelter protection is significant. Many existing fallout shelter spaces are vulnerable to fire. Problems involved are fire hazards within the shelter, noxious gases entering the shelter, hazards from buildings burning above basement shelters, and hazards of fire spread from surrounding combustible buildings.

Reducing the fire vulnerability of fallout shelters will require a program to: (1) inspect and rate existing and currently approved shelters, (2) locate shelters where fire risk is low, (3) protect shelters from within by the occupants, and (4) organize fire control, evacuation, or rescue efforts from without. Descriptions of these latter measures begin on page 48.

Inspecting and Rating Shelters

Present bases for rating fire vulnerability are limited to some general standards concerning construction characteristics and fire resistance of family shelters. Community shelter requirements specify that all fallout shelters "shall be constructed to minimize the danger of fire from both external and internal sources". (OCD Technical Memoranda for Minimum Technical Requirements for Family Shelters 61-1, Aug. 1962, and Technical Requirements for Fallout Shelters 61-3, Aug. 1964.)

Shelter ventilation standards included in OCD publication PG-80-10, Catalog of Shelter Components, July 1963, covers situations where the outside air is contaminated but not heated. There is no provision for ventilation when the outside air temperature is increased by fires in nearby structures.

The first essential step to reduce the fire vulnerability of shelters is to develop directions for inspecting and rating the shelter fire vulnerability. These could be developed by the Office of Civil Defense, using pertinent data from this report and from the work being done by Factory Mutual Research, Inc. Specifications could be written and the job contracted. The end product would be a handbook to guide local officials during their inspections. The handbook could also include advice on measures to correct certain types of vulnerability. These inspections and ratings could be done by qualified local officials in connection with their other related duties and with the expenditure of little additional cost. Inspection and rating could identify those shelters needing window covers, extinguishing and other equipment, and outline fire protection procedures for that particular shelter.

Correcting the fire vulnerability disclosed by the inspections and ratings would include such actions as installing fire-extinguishing equipment in the shelter, replacing combustible materials in the shelter, shielding windows, (previously explained) relocating shelters in areas away from heavy fuel loadings, and evacuation plans for shelters vulnerable to fire. Fire vulnerability information for each shelter should be available and used with other information when planning for fire defense. For example, information would be used in the Nuclear Fire Analysis described on page 74.

High-Expansion Foam Extinguishers in Shelter Buildings

High-expansion foam extinguishers show promise for protecting shelter occupants from fire threat. These devices would be located in shelter buildings and employed by the occupants, under competent leadership, to suppress fires. They can be obtained and installed for about $3,000 per unit. If one foam unit is assigned per 200 shelter spaces, the cost of equipping shelters in the three cities studied would be about $150,000,000. This measure should be explored further during Phase Two, NFCS. More information is needed about present capabilities for the internal defense of shelters against fire before proceeding with a high-expansion foam extinguisher program. Ways to reduce costs of this protection measure should be explored.

Shelter Fire Control Training Kit

An information kit to instruct occupants how to defend their individual shelters from fire is another measure with possibilities. Several potential circumstances support the need and usefulness of such a kit. For example: (1) shelter occupants will need to control all fires within the shelter building to keep the shelter tenable; (2) shelter occupants may need to suppress fires in adjacent buildings to prevent spread to their shelter; (3) professional fire leadership will not always be available within the shelters,

so the occupants will have to act on their own initiative. This measure has not been fully studied and should be explored in more detail during Phase Two, NFCS.

Organized Fire Suppression and Rescue

Controlling fires during and after an attack presents serious problems, nonetheless, selective control of fires must be achieved. It is difficult to visualize a fire prevention program effective enough to prevent all ignitions. Once started, small fires might coalesce into mass fires that would threaten lives and resources needed for recovery. Control measures will be needed, ranging from extinguishing small fires before they coalesce to controlling large fires, spreading on one or more fronts.

There is presently no effective way to prevent nuclear thermal flash from igniting rural fuels. In some sections of the United States, uncontrolled fires would spread over hundreds of thousands of acres during high-hazard conditions. Lives, towns, and resources would be threatened and many would be destroyed unless selective control measures were carried out.

Control of fires during and after a nuclear attack will present abnormal firefighting conditions. Control must be selective. Some areas must be left to burn, while control efforts will be

concentrated on high-priority fires where control will be effective. Timing will be important. The presence, anticipated presence, and duration of radioactive fallout will control the timing. Rescue of large numbers of survivors may be involved. For example, it may prove more feasible to evacuate persons from certain areas than to control the fire threat. Equipment capability and effectiveness will be reduced in blast areas. Finally, the public will be involved independently as well as in support of professional firemen in controlling fires.

It is important that the foregoing characteristics of nuclear fire control be understood by state and local governments, CD directors and planners, and the fire services. The Nuclear Fire Analysis (explained later) should clarify these characteristics for each community. The analysis should be used as a basis for planning preparatory measures. Measures planned in advance on the basis of these analyses will enhance the effectiveness of the fire services and thereby strengthen the capability of the United States to survive a nuclear attack.

The difficulties created by blast damage and fallout will present trying problems in controlling fires, but there will be opportunities for effective action. Examples include the following: (1) Communities not directly affected by blast or thermal ignitions

can take special fire precautions before radioactive fallout forces them to seek shelter. (2) Usually the thermal ignitions from a ground blast extend well beyond the 500-roentgen fallout range on the upwind side, if topography is uniform and weather is clear. This creates an opportunity for fire and rescue forces, when accompanied by effective radiological monitoring, to move into the disaster area on the upwind side and do effective work. Fallout originating from other explosions upwind might eventually compel these forces to seek shelter. Coastal communities where sea-to-shore winds prevail are in an especially favorable environment to plan this kind of action (see Figure 4). (3) Effective, selective fire control and rescue action is feasible for a short time — 30 to 45 minutes — in the downwind fire area beyond the 5 p.s.i. blast damage point. (4) In the case of an air burst, the area affected by thermal ignition is increased and the danger from fallout is lessened. Effective fire control throughout much of the disaster area could be possible. (5) Organized fire control action by the occupants to protect shelters from fire will be necessary and feasible at times. Control might include suppressing fires within the building and action to prevent adjacent fires from entering the building. The organized efforts by occupants of the shelters would avoid a forced choice between death by fire and a flight to the hazards of death or serious illness from radioactive fallout.

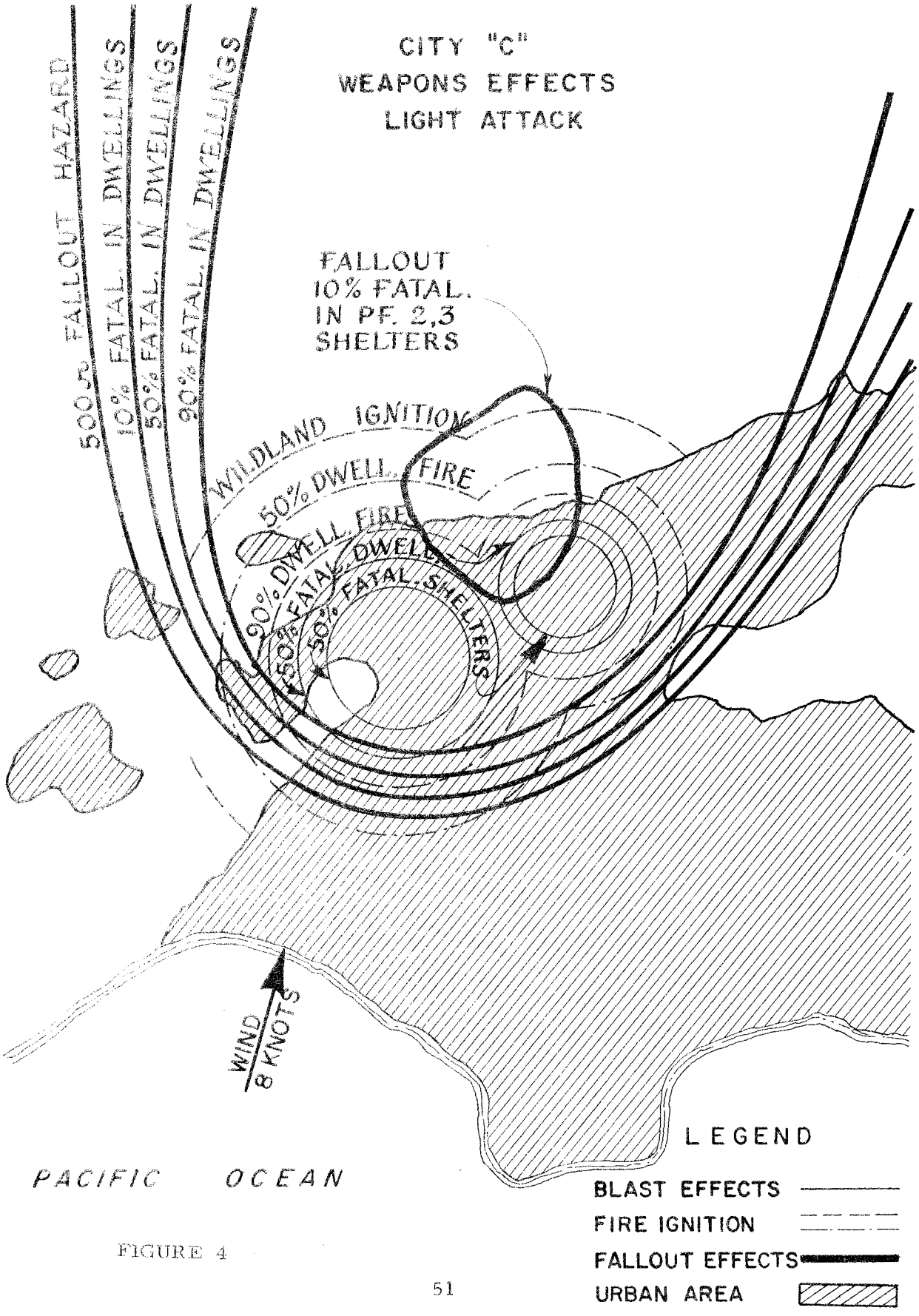

CITY "C"
WEAPONS EFFECTS
LIGHT ATTACK
500 R FALLOUT HAZARD
10% FATAL IN DWELLINGS
50% FATAL IN DWELLINGS
90% FATAL IN DWELLINGS
FALLOUT
10% FATAL.
IN PF. 2,3
SHELTERS
WILDLAND IGNITION
50% DWELL. FIRE
90% DWELL. FIRE
50% FATAL DWELL.
50% FATAL SHELTERS
WIND
8 KNOTS
PACIFIC OCEAN
LEGEND
BLAST EFFECTS
FIRE IGNITION
FALLOUT EFFECTS
URBAN AREA

FIGURE 4

Analysis was made by the study group of one large city subjected to hypothetical light and heavy nuclear attacks to determine the usefulness of organized fire suppression and rescue efforts. The attacks on this city were the same as those hypothesized in the study to assess the nuclear fire problem for the United States. The actual weather pattern of August 24, 1964 was used. This was a clear day with a 10-knot wind from the west. Assumptions were that the population had been warned of impending attack and occupied available fallout shelters throughout the city. No smoke screen, window covers, or other protection measures were in effect. All off-duty personnel had reported to their stations for the emergency. It was further assumed that excellent direction and control of emergency activities existed to provide the fire services with ample information on the location of weapon bursts, the areas of damage and fires, and overall operating instructions. Firefighting forces of other regions of the metropolitan area made themselves available when needed. Fire service personnel knew the location of the important fallout shelters in the area.

It should be noted that the foregoing ideal circumstances seldom exist in fact. Unless these are developed through support and training programs, the effectiveness of organized fire suppression and rescue efforts will be less than is demonstrated below.

In Figure 5 the light attack consists of one ground burst at the western edge of the city. This presents a difficult situation since the area of worst fire threat is immediately downwind from the ground zero. Figure 5 shows the areas where fire suppression and personnel rescue is most feasible. Considering that the fire personnel and items of equipment within this area, are able to travel there within the time limits available — 10 minutes to travel and 20-30 minutes to work before taking shelter — highly-organized and directed fire suppression and rescue operations could protect approximately 50 percent of the sheltered population from fire risk.

Figures 6 and 7 show the feasible fire suppression and rescue areas following the first and final waves of weapons delivery in a heavy attack. In this case the city is almost entirely consumed by blast damage and fire protection measures within the city are largely negated.

Effects of light attack by nuclear weapons on City "A"

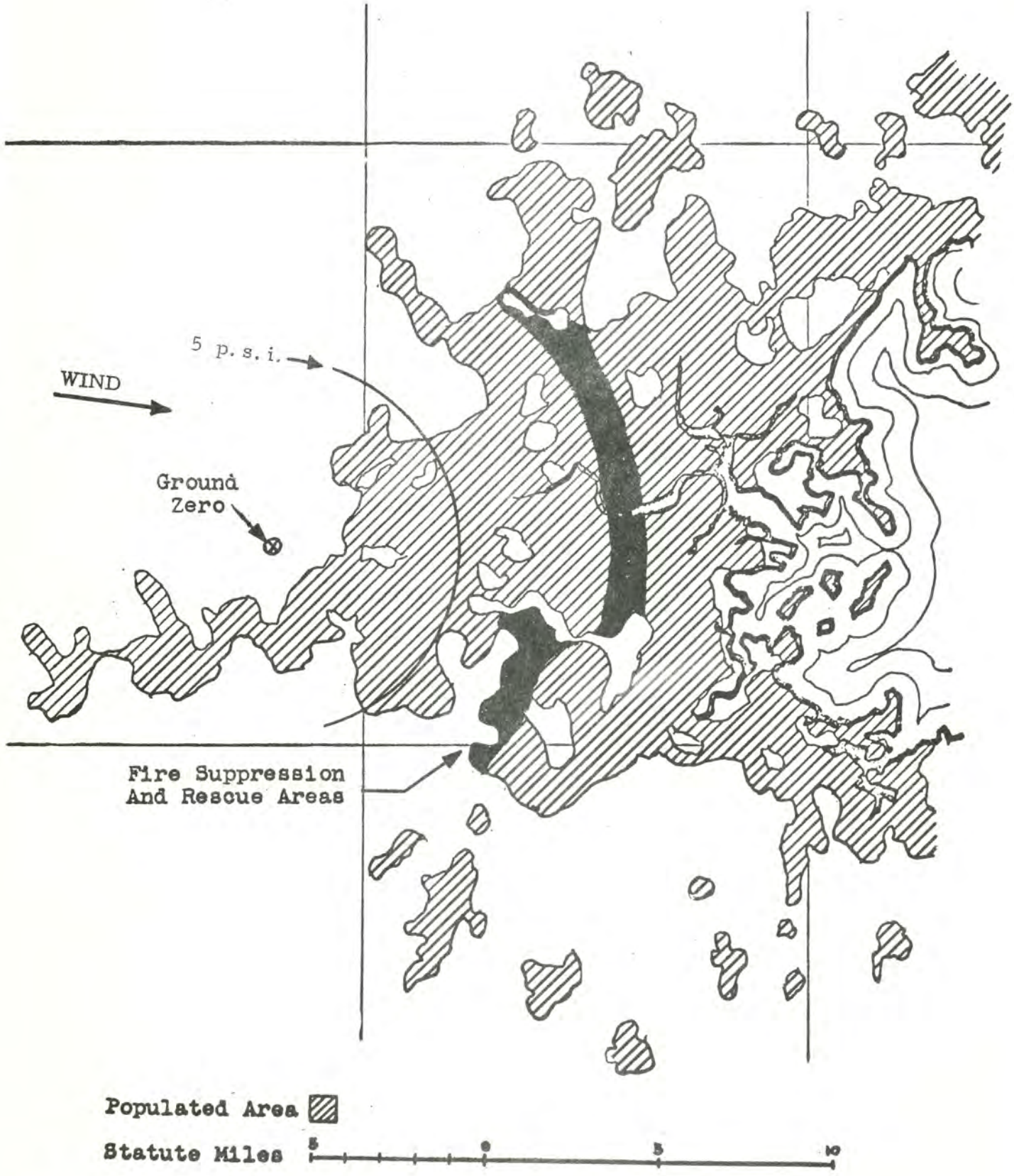


FIGURE 5

Effects after the first wave of Medium - Heavy attack by nuclear weapons on City "A"

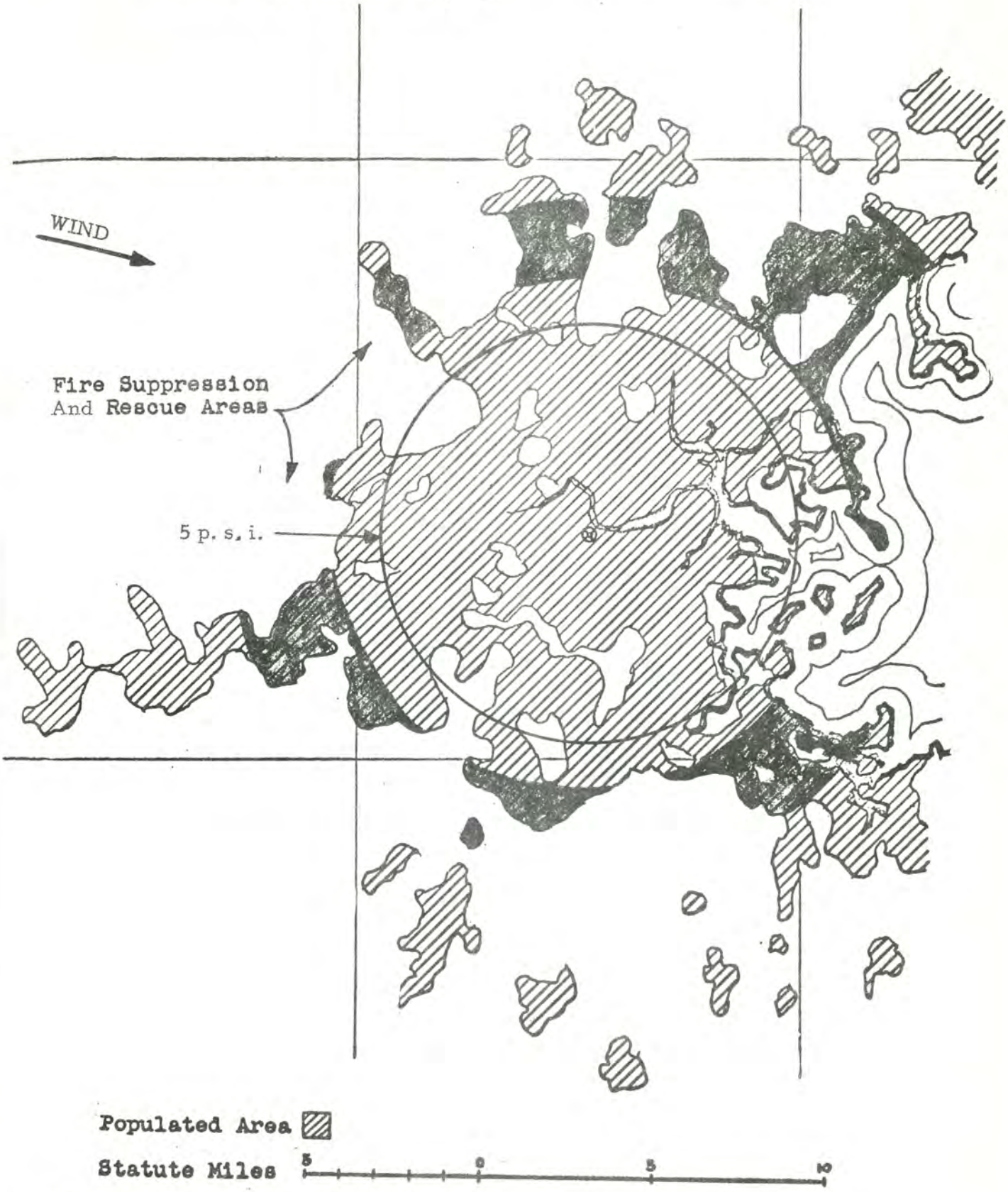


FIGURE 6

Effects after the second wave from Medium - Heavy attack by nuclear weapons on City "A"

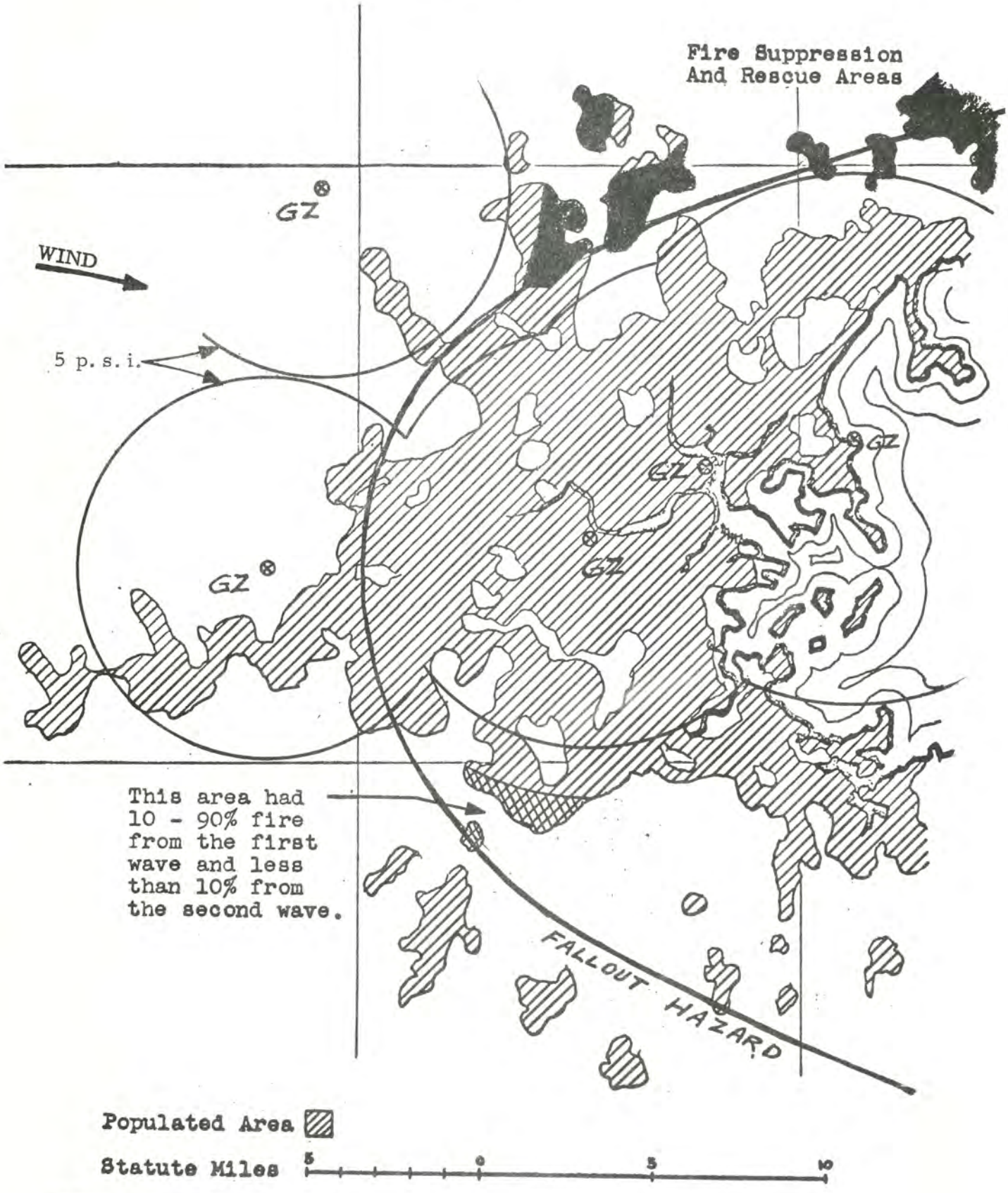


FIGURE 7

Organized fire suppression and rescue activities can be summarized as follows: In the regions of excessive rubble close to the bomb blast, the surviving firefighting forces are considerably restricted in their operations. Damage is widespread and the principal fire service role would be to attempt rescues and to move the population to safe areas, if any can be found in this disaster region. Most life-saving operations will be limited in this environment. Outside the area of impassable rubble the fire services should be directed to move to the fire perimeter. In the 3- to 4-mile ring beyond the fire perimeter, the fire forces should be directed back to the fire perimeter. At the perimeter, rescue and fire suppression may be undertaken with considerable likelihood of success. It is apparent, however, that success is critically dependent on a very high degree of planning, direction, communication, and coordination.

In an attack where only one or two warheads are detonated in a large city, a capable firefighting organization with optimum planning, direction, and coordination may rescue or remove the nuclear fire threat from as much as 5 percent of the city's population. In a heavy attack, especially with different arrival times for the attack weapons, widespread devastation and fallout will probably destroy most of the fire services' potential for fire suppression and rescue.

Existing professional and volunteer fire services provide the means to implement organized fire suppression and rescue. Their effectiveness depends on a high degree of planning, direction, communication, and coordination. It is extremely important that this capability be developed through the support plans and training described later in this report.

Organized fire suppression and rescue measures developed in this report include infrared mapping of nuclear fires, use of aerial fire retardants in protecting shelters from fire, use of aircraft as a fire defense tool, special equipment for suppressing nuclear fires, and support of the fire services by citizens.

Infrared Mapping of Nuclear Fires

Infrared techniques appear to be the most feasible means to map fires following a nuclear attack. Important phases of these techniques are nearly operational. The Office of Civil Defense and the Forest Service are presently working together to develop field procedures, plans, and methods for infrared mapping. The Forest Service, under a fire research contract, is preparing a report that will give detailed information about the use of infrared techniques. HRB Singer's current study, which is intended to assess present and potential infrared operating capability, might provide useful planning information as well.

Infrared detectors on high-flying aircraft are capable of mapping fires through smoke to provide a basic input essential for the fire defense intelligence system. The basic components are a scanner which receives the fire imagery and a printer which transcribes the imagery into picture form for operational use. Additional capabilities can be developed to telemeter the imagery to the ground. Nuclear fire mapping by infrared techniques will be needed for tactical and strategic purposes. Detailed imagery will be needed for tactical purposes in each disaster area created in the attack to provide a basis for taking selective fire control and rescue actions. It seems unlikely that this imagery can be made available for the critical period immediately following a weapon burst. It will be most valuable for planning fire suppression and rescue action in the immediate post-attack period. Thus far, this study has dealt primarily with tactical use of infrared mapping.

Strategic fire information could be gathered by mapping nuclear fires from high-flying jet aircraft equipped with infrared scanners and printers. This might be especially effective if coordinated with detection devices for nuclear detonation that would identify the general location of strikes. This would minimize the need to scan all areas and reduce aircraft flying time. Research presently being done by the General Electric Company may facilitate this development.

The tactical and strategic infrared mapping techniques described above can be useful only if a competent organization is functioning on the ground to receive and use the imagery. The support plans and training programs described later are intended to assure that ground organizations are capable of interpreting and using the imagery under nuclear-attack conditions. When infrared techniques are to be used, they should be included in the fire defense plans for each community or planning area, and key personnel should be trained to receive and use the infrared imagery.

Fortunately, infrared mapping techniques have current peacetime applications. Fire protection agencies can use these techniques to advantage for detecting and mapping peacetime fires. These users provide OCD with an opportunity, through cooperative financing and effort, to install equipment and train personnel. The infrared units[1/] could be used currently by the fire protection agencies, thus maintaining an up-to-date operating capability that could be directed to map nuclear fires if an attack occurs.

1/ A unit is one airplane equipped with scanner and printer.

Costs to develop the infrared mapping capability required for a nuclear attack are estimated to be $7,592,000. Effectiveness has not been specifically assessed for this measure in terms of lives or resources saved. However, infrared mapping is an integral part of the Austere, Moderate, and Comprehensive Programs discussed in Section VIII.

Use of Aerial Fire Retardants in Protecting Shelters from Fire

Experience with forest fires has demonstrated that aerial application of retardants can reduce fire spread in many types of rural fuels. Ignition from flying brands can be lessened by using retardants. Some of the lessons learned in rural fires can be applied to urban fires, but little is known about the effects of aerially-applied retardants on urban fires.

One conclusion resulting from studies of large fires made during Phase One is that aerially-delivered retardants are effective in protecting structures from fire under certain conditions. Additional study is needed to (1) determine the range of situations and conditions under which the retardant can be used effectively, and (2) determine the retardants most effective for shelter protection. New fire retardants are being developed continually and more effective retardants will probably be available in the future.

Using Aircraft as a Tool for Fire Defense

Aircraft may be used for intelligence, communication, aerial command, fire attack, rescue, movement of equipment and personnel, and shelter protection.

High operating and maintenance costs of aircraft preclude the maintenance of aircraft for civil defense purposes only with a few highly-specialized aircraft as possible exceptions. Special equipment such as infrared mapping units might need to be available primarily for civil defense. Generally, the plan should be to make the most effective use of currently available aircraft and supplement these with extra equipment and training personnel as needed.

The most effective role for OCD may be to (1) define the role of aircraft in nuclear fire defense, (2) encourage governors and state CD directors to inventory their potential nuclear disaster aircraft needs and current capabilities to meet the need, (3) inventory and "claim" the fire defense aircraft needed for the Nation, and (4) include use of aerial support in nuclear fire leadership training.

Light aircraft are available in the United States to supply nuclear fire disaster reconnaissance needs, provided the need is identified in advance and pilots are given some training for what must be done. Specialized equipment such as air tankers, helicopters, and infrared mapping planes is not available readily in sufficent numbers for nuclear fire needs. In the event of a nuclear disaster much of this equipment would at present have to come from Military sources. Thus it is important that these needs be identified in advance and plans and arrangements made for their use.

Aerial equipment needed for fire defense in nuclear disaster areas will vary according to the size and complexity of the fire defense problem in each area. A list of the aerial equipment typically needed for a disaster area where spreading fires present a major threat follows:

3 small helicopters
1 medium helicopter
3 air tankers
1 lead plane
1 reconnaissance plane
* 1/2 of 1 medium air transport for personnel
** 1/4 of 1 heavy air transport for cargo
* 1/2 of 1 infrared fire mapping plane
1 fire retardant mixing unit

Aerial equipment for strategic fire reconnaissance is not indicated in this estimate.

---

* 1 plane could serve fire needs for 2 disaster areas.
** 1 plane could serve fire needs for 4 disaster areas.

Special Equipment for Suppressing Nuclear Fires

Existing fire and rescue equipment in the United States is designed mostly for peacetime fire problems. The environment created by a nuclear attack suggests that study is needed to identify the equipment, or combination of equipment, that would be most effective for fire control and rescue in the nuclear aftermath. For example, the picture is one of considerable destruction near the burst point, an area where it is inconceivable that any operations, except shelter defense from within, could be performed until long after the attack. Farther from the burst point, the blast destruction is less, and at about the 5 p. s. i. line the rubble in many areas tends to become passable by vehicles. Within a large part of this region, and somewhat farther away, the frequency of building fires is very high. With increasing distance from the burst, the fire damage begins to diminish and there is a region of 10 percent to 90 percent fire damage which can be considered as a fire front. The probable frequency of ignitions in this fire-front area for one large American city is indicated in Table 4. In preparing this table it was assumed that no special preventive protection measures were employed. Beyond this region the incidence of fire drops rapidly. In the case of a surface-burst weapon, fallout will begin to arrive in about one-half hour, curtailing rescue and suppression operations.

TABLE 4

ESTIMATED FREQUENCY DISTRIBUTION OF IGNITIONS PER BLOCK AT FIRE FRONT

Number of ignitions per block	Probability of uncontrolled fire damage in area --- Fire Front ----					
	1%	10%	50%	90%	95%	99%
0	99%	90%	50%	10%	5%	1%
1	0	9	30	23	15	5
2	0	0	12	27	22	10
3	0	0	3	20	21	16
4	0	0	1	13	17	17
6 or more	0	0	4	7	20	51

Example: In the 99 percent fire damage area, an estimated 68 percent (17 + 51) of the blocks will require 4 or more fire extinguishers to save the block; as compared to the 50 percent fire damage area within the Fire Front where only 3 percent of the blocks have as many as 3 ignitions that need extinguishing.

In summary, the immediate post-detonation environment in the target area is characterized by numerous fires, varying degrees of impeding rubble, disruption of normal water supplies, persons in distress, and fallout which will impede operations.

Outside the target area fallout patterns will dictate the timing of fire suppression efforts and efforts to extend aid to the blast and fire-damaged areas. Fires can spread great distances and inflict damage to persons and resources during the period when the populace is forced to seek shelter from fallout. A tremendous tactical fire control problem could present itself to the survivors emerging from shelters, who collectively are faced with the task of rebuilding the Nation's strength. For example, under hazardous burning conditions, and if the fire services are pinned down by fallout, it is possible that fires will spread from the areas of direct nuclear effects to damage or destroy resources, rural communities, and small towns comprising 10 percent of the land area of the United States. Conventional peacetime fire control equipment, though helpful, will be inadequate to cope fully with the fire threat in the nuclear attack environment.

Needs for special equipment to suppress nuclear fires have been previously dealt with in this report. Use of aircraft and infrared techniques are examples. A study in depth would reveal other possibilities such as bulldozers to clear the way, means of transporting large quantities of static water to critical areas, and combined tanker-dozers.

The problem of adapting incompatible fire hose connections is the most serious barrier in interchangeability of tanker and pumper equipment and mutual aid. The fire services have done much to standardize hose threads, but standardization is far from universal. Designing more effective ways to connect fire hose should be an important part of the special equipment study.

The mutual aid and fire studies during Phase One and the experiences of fire services show a universal need for an improved communication command and dispatcher equipment unit. This unit would consist of a self-enclosed assembly of communications equipment, a fire control resource locater board, and other command post facilities needed by the fire manager and dispatcher. Needs are indicated for stationary, mobile, and portable units for transportation by air. These units should be considered as part of the special equipment study.

Developing special equipment needed for nuclear fire suppression and personnel rescue is extremely complicated. An initial study to identify the types and kinds of equipment needed, followed by more specific development projects to design the equipment, seems to be the most feasible approach. The National Fire Protection Association and the American Insurance Association could play a leading role in these studies.

Citizens' Support for the Fire Services

Opportunity exists for citizens to reduce the fire spread through action to prevent and suppress fires. This action is described, beginning on page 36 of this report. Effective citizen fire suppression actions include: (1) suppression of small fires before they coalesce and become large fires, (2) suppression of fires within or which pose a threat to shelters, and (3) supporting professional fire services in organized fire suppression and rescue tasks. Training citizens to take such action effectively is discussed beginning on page 100.

In addition to a training program, effective independent fire control actions by citizens or small organized teams of citizens could be enhanced by making fire-extinguishing equipment available. For example, citizens fire self-help kits might be designed and stock-piled for distribution during times of tension. Special

suppression equipment could be stocked such as stirrup pumps and fire extinguishers. The problems inherent in designing and distributing fire control equipment for use by a trained citizenry have not been examined comprehensively during Phase One.

Measures for Reducing Fire Spread

An examination of the fire environment following a nuclear attack suggests that the fire threat can be reduced substantially through long-range measures designed to minimize fire spread. These measures include community planning to minimize fire-spread potential in urban areas, and fuel-type conversion and firebreak planning in rural areas. Firebreaks, fuel types and density, and building density are key factors.

Community Planning to Minimize Fire Spread

A nuclear fire analysis would probably show that substantial parts of some American cities might need to be abandoned quickly following nuclear attack, if exposed to fires. Some of these highly-flammable areas are now undergoing rebuilding and redevelopment. There is conflicting expert opinion about the fire-spread potential inherent in modern city redevelopment. Some experts say, in essence, that all we need to do is follow present day building codes and our cities will be safe from fire. Others state with equal positiveness that many communities, even though they follow the codes, are building potential fire disaster areas.

Much of this controversy probably stems from lack of information about how fires spread through urban areas. More research is needed. In the meantime, America is building and rebuilding great cities. National guides are needed for local planners to use in planning urban renewal and extension to minimize fire spread. These guides are explained in detail beginning on page 83.

Reducing Fire Spread Potential in Rural Areas

No feasible measures have been found in the analysis that would prevent nuclear thermal flash from igniting numerous fires over substantial areas of rural fuels, if these fuels are dry and the weather is clear at the time of the attack. Selective fire control, timed to avoid fallout patterns, will help reduce the damage inflicted by rural fires. Increasing the effectiveness of organized fire suppression and reducing the fire-spread potential in rural fuels can be achieved by replacing flammable ground cover with less-flammable types and by constructing firebreaks at key locations.

Reducing spread potential by converting ground cover types in rural areas is extremely complicated. Much of this ground cover has critical importance for watersheds, recreation, wildlife habitat, and production of food and fiber. Conversion of ground cover types must provide for, and if possible enhance, these purposes. Erodibility of soils and their capabilities to sustain

different cover types are basic factors for consideration. Continued research is necessary to determine what are optimum measures and what ground covers will achieve the purposes to which the land is dedicated and at the same time reduce flammability of ground cover as much as possible.

Modification of rural fuels is being done in some areas by the U. S. Forest Service, by states, and other managers of rural lands. These measures could be intensified for Civil Defense purposes by identifying the metropolitan areas and areas containing the resources needed for survival that might be threatened by rural fires. Special-type conversion and firebreak measures could follow to reduce the rural fire threat to such metropolitan areas and key resources.

SUPPORT PLANS

Conclusions drawn from the studies of large fires and from mutual aid and command studies suggest that opportunities exist to improve fire control and rescue effectiveness if support plans are strengthened. Recommendations of fire experts support these conclusions. The analysis of the usefulness of organized fire suppression and rescue efforts discussed on pages 48-57, demonstrates that effectiveness in the fire-front area, near a nuclear detonation depends largely on support planning and training.

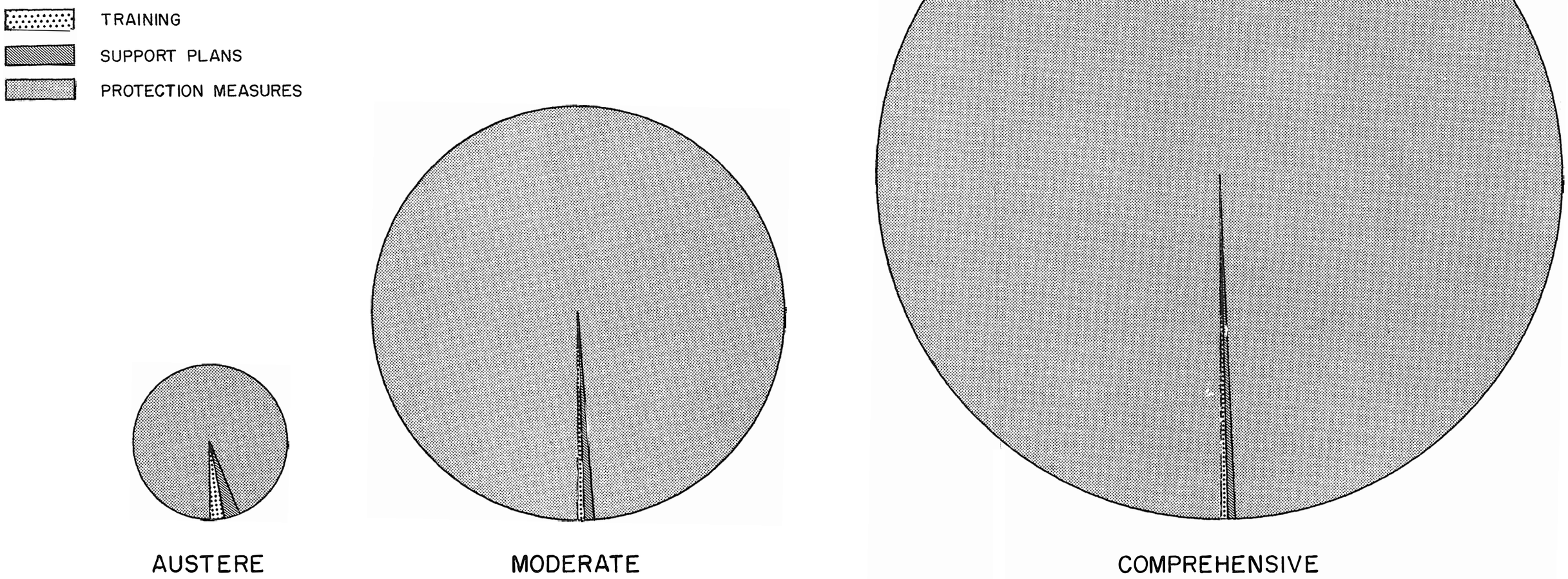
Support plans are necessary to carry out the protection measures effectively. Essential support plans are: (1) a nuclear fire analysis system, (2) fire-defense plans, (3) community-planning guides, (4) a nationwide intelligence system, (5) a nationwide communications system, and (6) strengthened professional fire staff leadership. This support, while essential, need only be a small percentage of the total program, (Figure 8). Effects of support plans are ultimately reflected in the reliability, quality, timing, and effectiveness of the protection measures. Therefore, the cost-effectiveness of each support plan was not assessed independently. The collective effectiveness of support plans is reflected in the overall cost-effectiveness estimated for the Austere, Moderate, and Comprehensive Programs.

In addition to providing guidelines, plans, systems, and professional leadership, a basic objective of support plans is to achieve an understanding of the magnitude, complexity, and compatability of the nuclear fire problem at the local level. This is not generally understood. A thorough community-by-community analysis of the nuclear fire potential, using guidelines and methods prepared by OCD, will help to achieve this understanding as well as to provide a sound basis for planning.

FIGURE 8

RELATIVE SIZE OF FIRE DEFENSE PROGRAMS AND OF TRAINING, PLANS AND PROTECTION MEASURES

(BASED ON COSTS TO OCD)



Nuclear Fire Analysis

The special features that would be affected by nuclear fires, vary widely in urban areas, rural areas, and combinations of these in the United States. Some are in potential target areas while others are not. Some cities contain potential conflagration areas, others are less susceptible to fire spread. These and other variations in characteristics suggest that a nuclear fire analysis be made of each city or other critical areas in the United States.

The Nuclear Fire Analysis would be a survey of the nuclear fire threat to each community. It would provide an inventory of each community's capability to cope with the threat, and an evaluation of the effectiveness of alternative protection measures considered. These local data, plus additional data, developed nationally and stored in OCD computers, would form the basis for community and nationwide fire defense planning and fire damage assessment.

The results of this Nuclear Fire Analysis will determine how much and what kind of fire protection measures the program should undertake for a given locality. For example, the Nuclear Fire Analysis for a community might identify areas where shelters might have to be evacuated quickly and abandoned if exposed to fire threat, and this would affect plans for operations during an emergency. Prevailing weather patterns might be identified that would reveal the

times of year when nuclear thermal ignition would be the most or least effective, thus influencing the timing of fire prevention campaigns. The possibility of receiving a nuclear strike could be analyzed and the results could influence the application of protection measures such as window shielding or smoke generation.

Nuclear disaster areas and their accompanying fires will not follow jurisdictional boundaries. Approximately 54 percent of the population of the United States are in cities with 50,000 or more. About 30 percent of the population are in rural areas and the remaining 16 percent are in towns ranging from 2,500 to 50,000 population, and in suburbs of large cities. Rural fires could be of great magnitude. Rural areas contain much of the industrial ability and the resources needed for survival as a Nation. A nuclear attack would create a series of nuclear disaster areas, each encompassing urban, surburban, and rural areas, and multi-jurisdictions. A Nuclear Fire Analysis should be programmed for each jurisdiction, and should include planning for each potential nuclear disaster area.

Components of the Nuclear Fire Analysis

A nationwide system is needed for conducting local nuclear fire analyses. This system should be carefully coordinated with existing damage assessment systems, and should include: (1) methods and instructions for collecting information describing the area, (2) provisions for OCD to furnish planning assumptions, (3) methods and instructions for using the information to predict attack effects on the area and to assess the effectiveness of the fire defense measures, and (4) provisions for programming key aspects of the system on computers.

Implementing the Nuclear Fire Analysis

It is estimated that five years will be required to fully implement a Nuclear Fire Analysis System on a national scope. The actual analysis for each community or nuclear problem area would not be achieved in five years. However, the system could be installed and be understood by local people, and a substantial beginning made in the analysis. Since the Nuclear Fire Analysis is the most feasible means to gather basic nuclear fire planning data, it will be most valuable if the system is designed and implemented without delay.

Steps essential to successfully install a Nuclear Fire Analysis System are:

(1) Prepare guidelines for data collection necessary for the Nuclear Fire Analysis in cities, rural areas, and in disaster problem areas. The urban fuel research being done by Gage-Babcock, Inc. will be most useful here.

(2) Develop analysis methods that are usable by local personnel and will standardize analysis procedures throughout the United States. The methods used in Phase One can be simplified and extended for this purpose.

(3) Develop model nuclear fire analyses and make them, plus staff help, available to states.

(4) Provide state Civil Defense planners with realistic attack assumptions. These could be extracted from the attacks in our model. The same attack models should be used for operational planning in all phases of Civil Defense — fire, police, rescue, decontamination, strategic, and others — throughout the United States. Thus, each CD planning venture will have a common basic point of reference. These attack data are classified; hence, responsibility, control, and methods for assembling the data should rest with the Office of Civil Defense. Ways of achieving objectives that are compatible with OCD policy should be developed.

(5) Implement the FLAME computer model as a planning tool. Continue to improve input data for this model. The ultimate goal should be to have this model and a comparable model for major cities programmed to gather fire damage information for strategic decision-making in emergencies. Decisions to commit a part of the Nation's air capability to counter a nuclear fire disaster is an example of the type of decision this information would support.

(6) Analyze nationwide fire effects of the hypothetical nuclear attacks and make pertinent portions of this analysis available to the individual states.

It should be recognized that many of the data used in the initial planning for a National Nuclear Fire Analysis will be ultimately programmed on computers and become the basis for a nationwide fire-damage assessment.

Costs and Impacts of the Nuclear Fire Analysis

Total costs to design and render operational a national Nuclear Fire Analysis System are estimated to be $13,061,000. Of this total, costs to the Office of Civil Defense are estimated to be $1,329,500, exclusive of the computer program. This assumes that OCD would design the system and finance 10 percent of the costs of implementing it. The remaining 90 percent of the implementing costs would be assumed by states and localities.

Recurrent costs after the system is in operation would be very minor. The computer program would comprise most of the work necessary in OCD.

Making a Nuclear Fire Analysis of the Nation would require major efforts by the fire services and Civil Defense officials. Such an analysis is so basic and necessary that these officials should welcome national guidance and systems programming.

Plans for Fire Defense

A recommended national fire-defense plan should be one of the major products developed in Phase Two, NFCS. This plan will be a principal appendix of Part E, Chapter 10 of the Federal Civil Defense Guide. It will contain the procedures and instructions necessary to implement an effective fire defense program in urban, suburban, and rural areas. The plan should incorporate the recommended protection measures, support plans, and training approved by OCD. These protection measures, training, and support plans each have individual limitations and only when they are all fitted together into an integrated whole, will optimum results be obtained. The national fire defense plan is the document through which we can achieve this integrated program and should be the guide for state and local officials in preparing fire defense plans.

The plan for each community and potential disaster area will be based on selected data as determined by the Nuclear Fire Analysis and be constructed within the framework of the national plan. However, certain basic elements should be a part of each plan. Overall command, fire command, staff, traffic control, mutual aid, communications, and intelligence are examples. Fire defense plans for each community and each potential nuclear disaster area provide the means to launch effective action in the emergency.

The OCDM National Fire Defense Plan (Annex 21) provided broad policy guidance for fire defense programs. However, it does not contain the procedures and instructions necessary to guide state and local units in a specific way. Existing state and local fire defense plans are reasonably adequate for "fire disaster typically experienced". Some plans are not accepted or used by the local fire services. All areas studied have arrangements for mutual aid of some kind, although many of these arrangements are too complicated to be effective for nuclear disaster fires. Command for "fire disaster typically experienced" is defined in all of the areas studied. Command for a nuclear disaster is defined in only one of five areas studied. Existing plans usually are not based on good inventories of fire control capabilities, knowledge of fire risk, and knowledge of what the nuclear fire problem potential is in the area. Table 5 presents an overview of important planning elements examined during Phase One.

Table 5

SUMMARY OF FINDINGS OF MUTUAL AID AND COMMAND STUDIES

ELEMENTS	Portland, Ore. & Vicinity	Michigan	Massachusetts	Washington, D. C. Metropolitan Area	Los Angeles County
Pre-emergency plans					
are prepared by	Fire Serv.	C. D.	Fire Serv.	C. D.	Fire Serv.
are approved by local government	Not yet	No	Yes	Some	Yes
are approved by fire service	Not yet	No	Yes	Some	Yes
are for severe emergency	Yes	Some	Some	Some	Some
defines levels of emergency	No	No	No	No	No
contains activation "trigger"	No	Declared emergency	No	No	Chief's judgment
names the commander	No	Yes	No	No	Yes
names the staff	No	Yes	No	No	Yes
includes job descriptions	No	No	No	No	Yes, imcomplete
includes priority guides	No	No	No	A few	No
includes fuel classification	No	No	No	No	No
includes shelter protection	No	-	No	No	No
includes pre-selected assignments	No	No	No	No	No
includes forest fire services	Yes	Partial	Partial	Partial	Partial
clearly define the authority and responsibility of all participants	No	No	No	No	No
vary widely within the area	Not in the proposed plan	No-State	Yes	Yes	No
Mutual-Aid Arrangements					
are in effect	Yes	Yes	Yes	Yes	Yes
are formal or informal	Both	Informal	Both	Both	Formal
need simplifying	Yes	Yes	Yes	Yes	Yes
consist of several agreements	Yes	Yes	Yes	Yes	Yes
are in one joint pact	Proposed	No	No	No	No
include reimbursement	Yes	Not clear	-	No	Yes
include liability	-	No	-	-	Some
need legislation	Yes	-	Yes	No	Yes
Fire Services Personnel					
percentage paid	Partial	50 percent	Partial	Partial	99 percent
chiefs are all paid	Partial	No	No	No	Yes
has reserve of command-trained affairs	No	Slight	No	Some	Yes
Dispatch and Locator System					
is adequate for normal	Yes	Barely	Barely	Yes	Yes
is designed for extreme	Proposes	No	No	Partial	Best
is hardened	Proposed	-	No	Partial	Partial
requires skilled dispatchers	Yes	Yes	Yes	Some do	Some do
Command					
is defined for "normal" fires	Yes	Yes	Yes	Yes	Yes
is defined for extreme emergency	No	State Law	No	No	Yes
changes with severity	Yes	Yes	Yes	Yes	No
goes to non-fire people	Yes	Yes	Yes	Yes	No
transition is provided	No	Yes	No	Not easy	Yes
Coordination					
is defined and understood	Some	Some	Some	Partial	Yes
is by Civil Defense	No	Some	Some	Some	Both
is by fire service	Some	Some	Some	Some	Both
transition "trigger" is defined	No	Declared emergency	No	No	Partly
Emergency Operating Center					
is available	Yes	-	No	Some	Yes
is hardened	Yes	-	No	Some	Yes
is staffed continuously	No	-	No	One is	Yes
is in daily use by fire service	No	-	No	One is	Yes
Training					
is joint	No	No	No	No	Some
is current	Some	Some	Some	Yes	Yes
is comprehensive	No	No	No	No	Yes
includes tactics	Yes	Yes	Yes	Yes	Yes
includes command	No	Some	No	No	Yes
includes shelter protection	No	No	No	No	No
includes evacuation	No	No	No	No	No
includes police	Some	No	No	No	Some
includes natural fuels	No	No	No	No	Yes
is done by	Fire Serv.	Univ.	Fire Serv.	Fire Serv. & Ext.	Fire Serv.
varies widely within area	Yes	Yes	Yes	No	No
facilities are adequate for training	No	No	No	No	Yes
Communications					
is adequate for "normal" circumstances	No	No	No	Yes	Yes
is adequate for greater emergency	No	No	No	No	No
includes several frequencies	-	No	Yes	Yes	Yes
includes a mutual aid frequency	No	No	No	Yes	Yes
includes a portable headquarters	No	No	No	No	Yes
Equipment and Supplies					
inventory maintained of fire equipment	No	No	Yes	Yes	Yes
inventory maintained of private equipment	Some	No	-	No	Some
adequate for "normal"	Barely	Yes	Barely	Yes	Yes
Other Problem Elements					
has legal problems in M-A	Yes	Yes	Yes	Minor	Minor
has reimbursement problems	Yes	-	Yes	No	No
has communication problem now	Yes	Yes	Yes	No	No
volunteer chiefs are a problem in command	-	-	Yes	Yes	No
autonomy is a problem in command	Yes	-	Yes	Yes	No
natural fuels critical - % days - est.	8 percent	11 percent	8 percent	4 percent	28 percent

If a nuclear attack upon the United States occurred, urban and rural areas would be encompassed by disaster simultaneously. Selective fire control and rescue actions during and after the attack would unite urban and rural fire control capabilities in a common endeavor to save lives and critical resources. Efforts to join these capabilities may be enhanced by a single national fire defense plan, instead of separate urban and rural plans. This concept should be explored fully during Phase Two, NFCS.

Preparing and implementing a national fire defense plan would not create major impacts on Civil Defense officials and the fire services unless the Nuclear Fire Analysis disclosed their previous planning base to be unsound. Model local plans could be developed and field tested by OCD during F. Y. 1966. These would become samples to guide fire defense planners throughout the United States. The total project costs, in addition to the NFCS work, for developing and coordinating nationwide fire defense plans are estimated to be $276,000. Of this total, costs to OCD to develop and field test sample plans and conduct training for state CD directors is estimated to be $26,000.

Guidelines for Community Planning to Minimize Urban Fire Spread

The concept of planning communities to minimize fire spread is explained under Protection Measures, beginning on page 69. An essential first step to implement this measure is to prepare national guides for use by urban planners. These guides could be prepared by the Office of Civil Defense in handbook form for the OCD professional guide series. The handbook would reflect OCD's policy and advice to local planners about fire vulnerability in cities and suggest ways to reduce potential fire spread through effective planning.

Existing codes and guides are believed to be effective in designing structures to minimize fire vulnerability, but local planners need guides and codes that deal with the probability of fires spreading from building to building. It would be desirable to include a section in the handbook explaining the nuclear fire-spread problem. Existing fire guides and codes should be studied and brief studies should be made to describe how fire-spread potential is presently considered in urban planning. Basic planning assumptions can then be made for the handbook.

Nationwide Fire Intelligence System

Present methods and organization for strategic and tactical scouting and intelligence are inadequate for large conflagrations such as are experienced in peacetime. These peacetime conflagrations usually occur singly, or if occurring in multiples, are usually confined to a single zone such as one or two states.

A nuclear attack would conceivably create several separate disasters simultaneously in one state and compound the problem by duplication in several states. Strategic decisions about where to commit critical fire control resources such as aircraft, trained personnel, and special equipment must be made at the state and sometimes national level. Fire situation information must be gathered and communicated to state and national headquarters for use in making these strategic decisions over broad areas. This information will result in wider use of scarce equipment. For example, an informed state CD director might use the same aircraft and mapping unit to cover three disaster areas.

Local fire efforts in a nuclear aftermath would be involved mostly in rescue efforts, protecting shelters from fire, and preventing coalescence of small fires into larger fires. Assessment of the total disaster and its accompanying fire would best be done outside the stricken area. An effective system is needed to assess the fire situation and communicate this information to command and coordinating officials.

An ultimate nationwide strategic intelligence system would include responsibilities for the detection of ground zeros, and communicating the information — independent of faltering communications — to a computer pre-programmed to predict the fire situation. More detailed fire assessment could be made of the target areas using aircraft equipment with infrared scanners. Infrared mapping is described under Protection Measures beginning on page 58.

After a nuclear attack, little time is available to take rescue and selective fire control actions in the fire-front area adjacent to a nuclear strike. Therefore, immediate post-attack tactical intelligence must be both rapid and accurate to be of value to the forces at the scene.

Special study is needed to develop the scope and content of a nationally-coordinated fire intelligence plan and system. An initial step in such a study would be to examine the presently assigned role of Military and other Government agencies for gathering intelligence pertinent to nuclear fires.

Costs to develop the plans for a nationwide intelligence system are estimated to be $22,000. This task could be done by OCD working cooperatively with the fire services. The costs of implementing the system could be assumed by the fire services and states, except for equipment and programs that qualify for OCD matching funds.

A Nationwide Fire Communications System

Much of the success of fire suppression, rescue, and shelter protection measures during a nuclear attack will depend on effective communications. The intelligence system will be effective only if communications can send the information to the central point where command decisions are made. A nuclear attack would create havoc in much of our existing communications system, but it can be assumed that radio equipment which survives the blast will be operable and at least partly effective. Communication problems may exist for a time following an attack. Fire studies made during Phase One suggest that too much communication may

aggravate the problem. These studies show that communications were adequate for normal conditions, but were not adequate for conditions imposed by three of the four fires studies. The reasons for these inadequacies are not clear, but conclusions from the fire studies suggest that poor operating procedures may be as detrimental as inadequate equipment.

The three most common communication problems identified in the fire studies were: (1) overloading of available frequencies, (2) separate frequencies not adequately tied together, and (3) lack of uniform procedure and terminology. The analyst further states: "poor communications resulted in inadequate dispatch and control of areas on all fires studied. A nuclear attack would likely pose two separate, yet related, communication problems: (1) extreme demands upon the communications net of the fire services, and (2) similar demands upon the EOC net that coordinates all the public services."

Scope, Content, and Plans for Nationwide Fire Communications System

A nationwide fire communications system is needed to utilize existing equipment most effectively during a nuclear attack. A special project will be required to develop the scope, and plans for the system. This could be done by OCD. The end product

would be a plan (an annex to the National Fire Defense Plan) to guide state and local authorities in developing communications capabilities that could be expanded to serve the demands of a nuclear attack.

In order to provide adequate communications during a nuclear attack, the communications system should be capable of (1) providing positive information between fireline, headquarters, mutual-aid partners, and the coordination center, (2) coordinating all public services to fully utilize their facilities in a disaster, (3) provide strategic and tactical communication for each disaster problem area without jamming others.

Standard Fire Terminology for the United States

Since nuclear disaster areas will often encompass several political jurisdictions, several fire services will have to coordinate their operation to achieve high-priority fire and rescue objectives. Operational effectiveness of communications could be improved by formulating a somewhat standard fire terminology for the entire Nation and training the fire services in its use.

It is not possible and probably unnecessary to standardize all fire-service terminology. Assembling a standard terminology would include (1) a study of terminology presently in common use, (2) identification of those terms that could and should be standardized,

(3) assembling the national terminology into a handbook, (4) review by the fire services, and (5) field-testing. National Fire Protection Association's pre-attack planning symbols might be a good starting point for this project.

Fire Service Radio Operating Procedures Handbook

Radio procedures are not well disciplined in many fire services. The results of the fire studies suggest poor radio operating procedures to be a major problem that should be overcome for efficient peacetime operations. Improved fire management and more available air time on each frequency will result from the disciplined use of effective procedures. Good radio operating procedures, commonly understood and used by all, will help the several fire services to work together effectively to meet the fire demands of a nuclear attack.

Preparing a standard fire service radio operating procedures handbook will require (1) a review of handbooks presently in use (adaptation of some will likely be possible), (2) assembling a pilot handbook, (3) an intensive review by the fire services, and (4) field testing and revision.

Professional Fire Staff Leadership

The protection measures and support plans discussed so far and the training discussed later can be more effectively implemented by establishing a professional fire staff to provide technical guidance to the approved Fire Defense Program. This professional leadership should be at the national level. Fire service leaders throughout the United States are not in full agreement that there should be comprehensive professional fire staff leadership at the national level, but such professional leadership has been recommended by groups who have studied the problem.

Such a professional staff need not have line authority over operating units. Neither would it duplicate such services as those offered by the American Insurance Association, National Fire Protection Association, International Association of Fire Chiefs, or other similar groups. Its charter would stress technical guidance, training, and related services including:

(1) Nationwide aspects of the Nuclear Fire Analysis.

(2) Nationwide nuclear fire plans, samples, and handbooks.

(3) National fire technical staff support center.

(4) National level nuclear fire leadership training.

(5) National program for training CD volunteer firemen.

(6) Problem analysis for special studies.

(7) Professional service in all aspects of disaster fires.

Minimum staffing required for effective national professional fire leadership is as follows:

1 Director

1 Fire Research Staff

1 Training Staff

1 Mechanical Engineer

1 Librarian

2 Technical Assistants

7 Clerical

Costs to maintain this staff are estimated to be $272,000 per year. This cost includes salaries, plus $12,000 per year for facilities and $100,000 per year for equipment, special studies, and operating supplies. These costs do not consider utilizing personnel who are already engaged and whose duties might be changed to encompass the fire leadership tasks.

How and where to establish the national professional fire leadership staff is not readily apparent. It seems logical that this leadership should be the responsibility of the Office of Civil Defense during wartime emergencies. Some alternatives that could be considered are (1) establish this leadership and service within OCD, (2) establish it in some other Government agency having the necessary authority or ability to get it through Presidential Executive Order,

(3) establish a multi-concerned agency such as a NATO-type group with fulltime continuing duties, or (4) arrange an independent leadership outside of the Government. An advisory group made up of personnel from OCD, CD, urban fire services, rural fire services, and fire organizations could be brought together during Phase Two, NFCS to recommend the most satisfactory organizational plan.

TRAINING

Implementing the recommended fire protection measures requires the best efforts of competent Civil Defense and fire service personnel, plus cooperation and action by an informed public. The most effective way to achieve this competency and cooperation is by a training program. There exists some precedent which shows the effectiveness of training in fire defense. The rural fire defense pilot training program (Project 107) has developed fire defense capabilities in areas where none existed previously. It is developing a set of training plans and aids that can be used throughout the country. Perhaps it is of even more significance that this Project is developing an understanding of the magnitude and complexity of nuclear war and of the necessary role of Civil Defense. The staff and command schools sponsored by OCD in 1960 and 1961

were similarly successful. Fire services met and trained together at the national level; therefore, they are able to work together more effectively in times of fire crisis.

Training is required to implement each of the protection measures discussed earlier. The most significant training programs needed are (1) A national fire technical staff support center dedicated to implementing fire research findings rapidly and effectively, (2) nuclear fire leadership training, (3) fire defense support firemen training, and (4) rural fire defense training.

National Fire Technical Staff Support Center

Through Phase One of the NFCS, investigators were impressed by (a) the amount of valuable, complicated, and sometimes conflicting research results gathered from the fire field, (b) the difficulty of locating all pertinent research results for a given subject, (c) the limited use being made of research findings in on-site operations, (d) the limited understanding of operating firemen about recent findings, and (e) the almost universal enthusiasm to use new knowledge if it could be made available in operationally-understandable terms. It should be noted that the

Harbor Project[1] said of this problem; "Failure to assure a higher degree of survival and more rapid recovery from attack is not the result of deficiencies in technical knowledge."

Much progress could be made in applying research findings, in sharing productive operational ideas and discoveries between fire services, and in preparing good-quality training aids by establishing a national fire technical staff support center. This center would support nationwide fire services. It would be staffed by and be a part of the professional fire staff leadership discussed earlier.

The primary duties of the center staff would be to:

1. Assemble in one place the published research pertinent to fire prevention and control.
2. Analyze this research and develop operational guides from it.
3. Develop lesson plans, audio visual materials, guides, and aids for training people to implement the research.
4. Maintain, publish, and distribute a catalog showing the current contents of the center library.
5. Establish communication channels to capture productive and innovative fire operational ideas and distribute them to all fire services.

1/ The Harbor Project - Office of Civil Defense, Aug. 1963.

Decision makers might be tempted to assume that this function could be served by university extension services, the Defense Documentation Center, or others. We know of no group presently organized to fulfill this center responsibility. First of of all, the center must be comprehensive. Secondly, it should be staffed with personnel who understand fire research, personnel who know the urban and rural firemen's problems, and personnel capable of creating effective training tools. Moreover, the center staff should be close to the influence of, and be organized to serve the fire operation. It would lose its effectiveness if it were buried in a big specialized information service. The recommendation is to narrow the gap between what is known and what is used in fire control by joining research understanding, operational insight, and training capability into a single coordinated operation.

The costs of establishing and maintaining the fire technical staff support center are included as part of the costs for national professional fire staff leadership. These are explained on page 91. The location and timing for establishing the center should be determined after the decision is made about the national professional fire staff leadership.

Nuclear Fire Leadership Training

Two separate but related levels of training are needed, one would be conducted nationally for high-echelon fire leaders, the other would be conducted locally for the Fire Staff who will plan and activate the local community's fire defense program.

National Nuclear Fire Leadership Training

National fire staff and command training sponsored by OCD has been very effective. This training has provided an opportunity for key members of the fire services to think and train on a scope necessary to combat nuclear fires. The University of Maryland and some local organizations have expanded this training. Effective as this training has been, the magnitude and complexity of nuclear fires is not yet generally understood by fire services. This training should be re-activated on a broader scale. The scope of the training should be expanded to include all phases of the nuclear fire problem. Pre-attack planning, control and rescue operations during the attack, and operations during the recovery period should be covered. Attack gaming and definition of the resultant fire program should be covered in enough detail to give the trainees insight into the nationwide problem.

National nuclear fire leadership training would be for those fire professionals who are leaders at the state level or who would be the fire staff officer in charge of coordinating fire operations in a disaster area. When trained, these men would be capable of conducting nuclear fire analysis, preparing local fire defense plans, choosing and implementing nuclear fire protection measures, serving as fire staff or command officer in major disasters, and serving as staff at the state or zone level.

It is estimated that 537 fire professionals of the type who would receive national nuclear fire leadership training are needed to cope with fires stemming from a medium or heavy nuclear attack upon the United States. Assuming that one professional could be trained at a cost to the U. S. Government of $1,328, the total cost to develop the needed capability is $713,100. A continuing training program to maintain this capability would cost approximately $71,310 per year.

A combination of training efforts will be necessary to train the leaders for nuclear fire direction. The Office of Civil Defense might hold some courses at its staff colleges. Contracts could be arranged with universities having the essential staff and facilities. The fire services could conduct some of the training.

Essential first steps are to (1) design a course, (2) develop training materials, (3) conduct pilot training, and (4) revise the materials. These revised training materials will become the guides for the institutions conducting the training.

Local Nuclear Fire Leadership Training

The Nuclear Fire Analysis (page 74) suggests that each community should examine its nuclear fire vulnerability: inventory its existing and potential fire-control resources, key resources, and community shelters; relate all these to the probable effects of a nuclear attack; and then plan for and prepare the most effective pre- and post-attack protection measures. This localized approach requires an understanding of the nuclear fire problem by community fire leaders, plus an ability to effect rapidly the plan for their respective areas under trying conditions. One conclusion drawn from the study of four large fires states, "Pre-emergency plans should be problem-oriented, i.e., define the problem that might occur, consider the capabilities and potential capabilities available; then plan, organize, and train to use them fully to cope with the problem. That is, if city firemen should fight both brush and urban fires, then they should be so trained".

Local leadership training to provide nuclear firefighting capabilities would contain subject matter similar to national nuclear fire leadership training, but it would be concerned with specific local problems and plans. It would train persons who will jointly face the fire aspects of the disaster. This training could be developed as an "offshoot" of national nuclear fire leadership training. The national course could contain subject matter and instructions to help the graduates arrange and conduct local training in their home units.

Guidelines could be prepared by OCD to expedite this training. The training could be conducted best by state and local CD directors or the fire services. In some localities it may be feasible to contract this training to local universities. However, if this is done, great care should be taken to keep the training local and problem-oriented. The training should not be abstract.

After training, the participants should be capable of (1) conducting local nuclear fire analyses (2) analyzing the potential nuclear fire threat in their areas and choosing the most effective protection measures, (3) developing fire defense plans, (4) implementing pre-attack protection measures, and (5) directing suppression and rescue operations as discussed under Organized Fire Suppression and Rescue beginning on page 48.

Organized Citizens' Fire Defense Training

In a nuclear attack the initial fire situation would probably be characterized by numerous widespread small fires. Fire service capabilities would be reduced or seriously limited by blast effects. These factors, and the findings from the fire studies make a strong case for training and equipping citizens to extinguish fires in an organized way.

Feasible action by the citizens to prevent and suppress fires includes; (a) applying measures to prevent ignitions, (b) suppressing small fires before they coalesce and become large fires, (c) suppressing fires within or threatening shelters, and (d) supporting professional fire services in organized fire suppression. The citizens fire extinguishing and prevention program described under Protection Measures, (p. 36) will, among other things, help prepare the citizens to implement (a) and (b) above. Implementing actions (c) and (d) above requires that a portion of the citizenry be trained to attack fires in an organized way, sometimes under the supervision of the fire services and sometimes in small crews independent of fire staff supervision.

Supervision of citizen firefighters by competent fire service personnel is certainly desirable, but a nuclear attack would create fire situations whereby the citizenry themselves could reduce the

fire threat significantly if they had sufficient training. A typical urban situation where trained citizens could help the fire services in an organized way is described beginning on page 52. One significant conclusion drawn from the study of four large fires states: "Effective initial independent action can be cited on all four fires. Trained individuals acting on their own initiative can be reasonably effective in handling limited fire suppression activities until a central command is established. Untrained individuals acting independently are much less effective and may even jeopardize their own safety as well as effective control action by fire-suppression agencies".

Fire Defense Support Firemen Training

Support firemen could be trained to assist regular firemen and to act independently as needed in urban areas. The Nuclear Fire Analysis for each area will disclose the approximate number of these support firemen needed and will give some idea of the type of situation they will face. Thus, the training can be tailored to the potential demands.

An available source of trainees in each area should be assured before training begins. In many communities, industrial and institutional personnel can be formed into organized teams and brigades and trained together. Much of this is already being done. Where it is done, the task ahead is to add the nuclear fire aspects to the

training. Neighborhood teams will need to be organized and trained. It should be noted that the most effective role of these citizen support firemen in urban areas will be to extinguish or control the spread of fires at or near their shelters or in their neighborhoods. Accordingly, geographical distribution of trainees, including on and off-the-job locations, is important. For example, some housewives might receive the training in suburban areas which are vacated by working husbands during the day. Trainees will need an opportunity to practice in order to maintain capability. Drills could be arranged by the fire services, and some support firemen could participate with the fire services in control of peacetime fires.

The Office of Civil Defense can promote this training by developing the program content and training materials for use by the fire services to train citizens. The Civil Defense fire training package, contract OCD-OS-63-135 (Oklahoma State University), has the potential to provide these training materials. The fire services, working with local CD officials, could do the training. Assuming that the Civil Defense fire training packet already under contract will provide the training materials, the cost to OCD to develop a training program is estimated to be $15,000.

There is not full agreement among the fire services concerning the value of citizen support firemen, but substantial encouragement for this measure does exist. Much fire service support can be gained if development of sound understanding of the nuclear fire problem on the part of the fire services precedes the training. The training materials being developed by the Oklahoma State University could be helpful here. As with other citizen-participation measures, the citizenry will have to understand the worthwhileness of the training if they are to be receptive to it. This understanding can be developed by explaining the nuclear fire problem fully to neighborhood residents, or relating the training to day-to-day fire activities, or both.

OCD pamphlets Fallout Protection, What to Know and Do About Nuclear Attack, Firefighting for the Householder, and Home Protection give excellent guidance to the public concerning fires. These should be revised slightly to place more emphasis on extinguishing small fires before entering the shelter.

More detailed information about how to implement Fire Defense support firemen training can be developed in Phase Two, NFCS. This information could include an assessment of equipment needed to make trained Fire Defense support firemen effective.

Rural Fire Defense Training

Rural fire defense training is similar to urban firemen's defense support training in that the objective is to qualify enough citizens to take the action needed to reduce the rural fire threat to acceptable limits. Results of the Rural Fire Defense Training Project OCD-PS-64-107 are very encouraging.

Rural Fire Defense Project 107 is a pilot project. Its ultimate objective is to develop an effective way to organize small crews under competent leadership and to train them so they can effectively prevent and suppress fires throughout rural America in a wartime situation.

Basic assumptions underlying Project 107 are that uncombated fires starting in rural areas, or spreading from urban centers, could inflict damage to personnel, fallout shelters, livestock, crops, strategic food stores, industrial resources and timber, and related resources. Fire, smoke, and debris would disrupt communications, transportation, and air operations vital to national defense and survival. Attack modelling and the large fire studies conducted thus far show these assumptions to be sound. In addition, these studies indicate an especially serious problem in areas where urban population is dispersing into adjacent rural areas containing dangerous fuels.

Project 107 includes pilot-training programs in five states - Colorado, Oregon, Florida, Missouri, and Kentucky. Partial finances are included for developing a mobile and portable fire training simulator. The Project has good acceptance at all levels in the pilot states. This Project shows promise for achieving fire protection readiness where none previously existed, for training people to cope with nuclear fires and related conditions, and for developing awareness of Civil Defense needs in rural areas.

Project 107 should be continued and expanded until rural firemen are trained in sufficient numbers to meet the demands of a nuclear attack. This training program appears to have universal acceptance from rural fire services, political jurisdictions, and the public.

RESEARCH AND DEVELOPMENT

Selected nuclear fire research findings were summarized during Phase One and pertinent findings were reduced to operational guides. These operational guides are the bases for a large part of the analyses and recommendations in this report. The complete Research Summary and Analysis is available in the NFCS library.

The Research Summary and Analysis serves two primary purposes: (1) to supply basic information for defining the fire problem following a nuclear attack, and (2) to provide guidelines for applying research findings to an operational fire program.

Initially OCD provided the following documents as a partial basis for the Research Summary:

Fire Aspects of Civil Defense - TR-25, Jul. 1964, OCD

Nuclear War and the Urban Fire Problem - The Dikewood Corporation, Feb. 20, 1964.

An Approach to Trans-Attack Fire Suppression in Urban Areas - IIT Research Institute, Mar. 1964.

In addition to these documents, selected research was summarized from the following sources:

1. Research done by the U. S. Forest Service relating to nuclear fire problems.

2. Other published research pertinent to the NFCS.

3. Current, unreported research underway. Interviews and meetings were held with OCD contractors working in the field.

A complete bibliography of the research reviewed is included in Reference No. 5, of the Analytical Report beginning on page 32. Time was insufficient to summarize all pertinent research during Phase One. Additional pertinent research will be reviewed and analyzed during the remainder of the NFCS.

Continued research and development is needed to up-date and improve measures to limit the nuclear fire threat. This includes basic and applied research to fill in existing gaps in knowledge of nuclear fire phenomena, special studies, and methods and equipment development to make implementation of an effective nuclear fire program possible.

The research review emphasizes why it is difficult to formulate operational policies concerning the importance of fire as a destructive agent in a nuclear attack aftermath. While there is basic agreement on some aspects of fires caused by nuclear weapons, the very nature of the problem precludes setting hard and fast rules that meet with complete acceptance by others working in the field. Some reasons for this are obvious; only limited weapons effects testing is currently possible and this must be replaced by theoretical weapons tests; weaponry in a constant state of change from both delivery and defense standpoints, fire susceptibility of individual buildings and areas change; and current research is providing new answers to old problems which result in wide diversity of accepted theories.

Knowledge Gaps

While the research summary and analysis is not complete enough to form the basis for a research program, several knowledge gaps were identified and these suggest a need for additional research.

A few examples follow:

Atmospheric transmissivity.--Information is lacking that will permit consistent, accurate determination of ignitions resulting from air bursts of nuclear weapons of various yields, at various altitudes, and under a wide range of weather conditions.

Primary vs. secondary ignitions.--There is disagreement concerning the importance of thermal pulse fires in relation to fires resulting from blast effects.

Urban fire spread.--There is a variation in estimates of fire spread through urban areas. Existing fire-spread models differ as they are based on a variety of assumptions.

Fire spread in natural fuels.--More precise data are needed to predict fire spread through wildland fuels more accurately. Weather, fuel moisture, and fuel arrangement vary from one region to another and these are limiting factors in accurate fire spread predictions.

Measures to reduce fire spread in rural areas.--Research should identify the region throughout the country where the various combinations of natural fuels and critical fire weather combine to produce hazardous situations requiring special attention. Hazard reduction, firebreak construction,

and converting ground cover to less flammable types requires research to define the optimum fire measures which are compatible with the purposes to which the lands are dedicated.

In summary, research is needed (1) to identify more effectively the relationships between weapons effects and the variables of weapon yield, height of burst, attenuation of the thermal flash by the atmosphere, pulse shape and duration, season of the year, and fuel ignition characteristics; and (2) to improve the basic input data for urban and rural fire spread models, and develop a model that will provide realistic and reliable fire spread information for combination urban-rural areas.

Special Studies, Methods Development, and Equipment Development

Special studies, methods development, and equipment development are needed before many of the recommended protection measures, support plans, and training plans can be implemented. These studies are included as part of the Austere, Moderate, and Comprehensive Programs (Section III, Summary of Recommendations - Tables 1, 2, and 3.) Additional measures require further study and testing to see if they have potential value. These studies and developmental projects are listed below and referenced to Section VI of this report where each is discussed in more detail:

1. Develop a product for treating combustible home furnishings with fire retardants, (p. 38).

2. Field test the smoke generation system, (pp. 40-41).

3. Develop window-shielding equipment and test its reliability, (pp. 41-44).

4. Study the operational effectiveness of using high-expansion foam extinguishers for defending shelters from fire, (p. 47).

5. Perfect field procedures, plans, and methods for mapping nuclear fires with infrared devices, (pp. 58-61).

6. Study the effectiveness of aerially-delivered fire retardants in protecting shelters from fire, (p. 61).

7. Identify the equipment and combinations of equipment, that would be most effective for fire control and rescue during and following a nuclear attack, (pp. 64-68).

8. Develop scope and prepare a plan for a nationwide fire intelligence system, (pp. 84-86).

9. Develop scope and prepare a plan for a nationwide fire communications system, (pp. 86-88).

The high cost of protection measures required to cope with the nuclear fire threat suggests a need for a comprehensive project to design new and more effective ways to stop fires. This could proceed concurrently with the action program recommended in this report. A special study is needed to see if such an effort is justified.

Fire service personnel helping during Phase One of this study expressed concern that structural and wildland fire research currently being conducted was not oriented more toward priority problems identified by the operational fire services. They suggest the establishment of a national fire research advisory group made up of fire service representatives from those agencies actively engaged in fire control. We have sufficient information to comment on these problems at this time.

VII. THE RECOMMENDED FIRE DEFENSE PROGRAM

A major purpose of this report, in addition to defining the nuclear fire problem is to recommend the content and direction for the OCD fire program, and provide acceptable alternatives. Potential elements of the OCD fire program are discussed in Section VI. Costs of developing and implementing these elements are summarized in Section VIII. Although of value, each of these elements by itself is inadequate to meet the fire threat. The greatest potential for saving lives and resources is achieved by combining several elements into an integrated program that includes necessary support plans and training.

RECOMMENDATIONS

Three alternative fire defense programs are presented and described later in this section. These programs - Austere, Moderate, and Comprehensive - are the results of the study group's search for the most effective combination of protection measures, support plans, and training that can be adapted to the varying conditions of budget, public support, and attack threat. It should be noted that the most effective measures require advance planning and ample time to install.

The authors recommend that OCD begin with the Austere Program. In this way procedures can be developed, equipment designed and tested, plans made and training arranged without the expenditure of large sums of money. The Austere Program can be expanded into a Moderate or Comprehensive Program on the basis of need and as field tests and experience validate the recommended protection measures.

Each alternative fire defense program has three phases; an initial phase, an interim phase, and a full-development phase. The initial phase is for the F. Y. 1966. The interim phase is for the F. Y.'s 1967-68. The full-development phase is the period of time required after F. Y. 1968 to fully implement the program. A summary of these programs appears in Secion III, Tables 1, 2, and 3. A detailed description of each phase of each program follows.

THE AUSTERE FIRE DEFENSE PROGRAM

The objective of the Austere Program (see Table 6) is to provide as much life and resource-saving capability as possible within a modest budget. Only the most basic and least costly fire protection measures, support plans, and training are included.

Table 6

ELEMENTS OF THE AUSTERE FIRE DEFENSE PROGRAM

Protection Measures: 1. TV and radio information kit for Citizens' Fire Extinguishing and Prevention Program 2. Low-cost window shielding in shelters and other buildings 3. Shelter Fire Inspection and Rating Program 4. Infrared mapping of nuclear fires
Support Plans: 1. Nuclear Fire Analysis System 2. National Fire Defense Plan 3. Guidelines for community planning to minimize fire spread 4. Nationwide Fire Intelligence System 5. Nationwide Fire Communications System
Training: 1. National Nuclear Fire Leadership Training 2. Rural Fire Defense Training

The Initial Phase

Protection Measures. -- Development projects dominate program activities during F. Y. 1966. The TV and radio information kit for the citizens' fire prevention program would be developed. Low-cost window shielding would be developed to the point of field testing. Guides and instructions would be prepared for inspecting and rating the fire vulnerability of shelters and a program would be designed and activated. Airplanes would be equipped with infrared scanning and printing equipment to be used in developing nuclear fire mapping procedures. Large fires would be mapped to test the procedures. Key personnel would be trained to map large fires with infrared equipment.

Support Plans. -- Guidelines and methods for a nuclear fire analysis system should be prepared during Phase Two, NFCS. These would be field tested in F. Y. 1966 by preparing a nuclear fire analysis for three typical communities. This would be done in cooperation with local officials. One nuclear fire analysis could center around one of the three large cities studied during the Phase One of this Study. Many data

already gathered could thus be used. Another analysis could center around a medium-sized city affected by fallout but not blast. The third analysis could center around a target area encompassing several small rural communities. These nuclear fire analyses would test the guidelines and methods developed in the NFCS and provide samples to guide OCD and CD officials.

The national fire defense plan will be completed in Phase Two, NFCS. Sample urban and rural fire defense plans should be developed during the initial phase of the Austere Program. These would be developed in consonance with the national plan. Plans could be developed for the same communities used to field test the nuclear fire analysis system. Data from the Nuclear Fire Analysis would be the basis for plans for fire defense.

Training. -- A program for national nuclear fire leadership training at the national level would be developed and would include preparation and field testing of training materials. Arrangements would be made to begin doing the training in F. Y. 1967.

Rural fire defense training would continue at the present level through the initial period. Studies would be made to determine (a) how many rural firemen should be trained, and (b) which geographical areas have the most urgent need for rural fire defense training. With this information available, plans can be made to expand rural fire defense training.

Cost. -- Nationwide OCD expenditures during the initial phase of the Austere Program are estimated to be $442,100. The foundation will be laid to develop substantial life and resource-saving capability during the Interim Phase.

The Interim Phase

Protection Measures. -- The citizens' fire extinguishing and prevention TV and radio information kits would be distributed to national networks and states to use if attack threatens. The low-cost window shielding would be field tested by stocking shelter buildings in a medium-sized city and conducting drills. All currently approved shelters would be inspected and rated for fire vulnerability, and corrective measures started. Procedures for infrared mapping of nuclear fires would be fully developed. At least 10 percent of the operational capability needed for mapping potential nuclear fires would be achieved.

Support Plans. -- An understanding of the Nuclear Fire Analysis would be achieved by the end of F. Y. 1968 and many communities would be conducting their own analyses. Some would have completed them. The national fire defense plan would be published with states and local communities modernizing their plans as they completed their Nuclear Fire Analysis. Guides would be developed during this period to help plan, build, and rebuild communities to minimize urban fire spread. Plans to guide the development and use of a fully-integrated nationwide fire intelligence system would be prepared.

Training. -- National nuclear fire leadership training would qualify 134 nuclear fire experts representing 25 percent of the nationally trained leadership needed to cope with potential nuclear fire. Rural fire defense training would prepare a substantial number of persons to defend rural areas from fire.

Cost. -- OCD expenditures during the interim phase are estimated to be $4,640,925. The total three-year — F. Y. 1966-68 — OCD investment would be about $5,083,025. This investment will provide a good start in developing the Austere Program's capability to protect lives and resources from fire risk.

The Full Development Phase

Protection Measures. -- Low-cost window shielding would be stocked in a substantial number of shelters by the end of F. Y. 1970. Publicity campaigns would be carried out in the cities urging the citizenry to have window shielding supplies in readiness in their homes and places of business. The remaining window shielding protection would be implemented after 1970 during a time period dictated by available finances, public support, and threat of attack.

By 1970 the shelter fire inspecting and rating program would be an integral part of locating and planning new shelters. Twenty-six infrared scanning and printing units would be operational by the end of F. Y. 1970. Approximately 17 of these could be used currently by fire protection agencies if they have the finances to do so. Twenty-six ground receivers would be operational and personnel would be trained to use these units.

Support Plans. -- The nuclear fire analysis system would be fully implemented by F. Y. 1969. By the end of F. Y. 1970 nuclear fire analyses would be completed for 50 percent of the communities or planning areas in the United States. The remaining 50 percent would be achieved as soon as possible after F. Y. 1970.

Community planning guidelines would begin to take effect during this phase. Plans to guide the development and application of a nationwide fire communications system would be prepared.

Training. -- An additional 134 nuclear fire leaders would receive national-level training by 1970, bringing the total trained leadership to 268. After F. Y. 1970 a total of 67 fire experts from over the Nation would receive nuclear fire leadership training each year until the full requirement is met. After that, 54 fire experts would be trained each year to offset attrition.

Rural fire defense training would be operational nationwide by the end of F. Y. 1970, and would continue to strengthen rural fire defense after 1970.

Cost. -- The OCD investment in the Austere Program is estimated to be $11,716,000 by the end of F. Y. 1970. By this time a substantial portion of the program's potential to protect lives and resources from fire risk will have been developed. The total OCD investment to make the Austere Program fully operational is estimated to be $41,178,000. (See Section VIII)

THE MODERATE FIRE DEFENSE PROGRAM

The objective of the Moderate Program (Table 7) is to provide life and resource-saving capability to the point where the balance between costs and losses are acceptable. Several elements are the same as in the Austere Program. Prescribed additional or more effective elements are included. Implementation time is compressed to provide a greater state of readiness by end of F. Y. 1970, than is provided in the Austere Program.

The Initial Phase

Protection Measures. -- Except for window shielding and aerial fire protection for shelters, the protection measures used in the Moderate Program are the same as in the Austere counterpart. Window shielding, tailor-made to partially withstand a blast of 5 p. s. i. from multiple detonations, would be studied.

Support Plans. -- Field testing the nuclear fire analysis system and fire defense plans in the Moderate Program is the same as in the Austere Program. Preparation of plans to guide the development of a fully-integrated nationwide fire intelligence system is moved ahead to the initial phase.

Table 7

ELEMENTS OF THE MODERATE FIRE DEFENSE PROGRAM

Protection Measures:

** 1. TV and radio information kit for Citizens' Fire Extinguishing and Prevention Program

2. Tailor-made window shielding in shelters and other buildings

** 3. Shelter Fire Inspection and Rating Program

* 4. Infrared mapping of nuclear fires

5. Study effectiveness of aerial fire retardants for protecting shelters

Support Plans:

* 1. Nuclear Fire Analysis System

** 2. National Fire Defense Plan

** 3. Guidelines for community planning to minimize fire spread

* 4. Nationwide Fire Intelligence System

* 5. Nationwide Fire Communications System

6. Professional fire staff leadership

Training:

* 1. National Nuclear Fire Leadership Training

* 2. Rural Fire Defense Training

3. Fire Technical Staff Support Center

4. Fire Defense Support Fireman Training

* Same item as Austere Program but time phasing is compressed

** Same item, time phasing, and scope as Austere Program

Training. -- The national nuclear fire leadership training is the same as in the Austere Program. Rural fire defense training is accelerated to become operational during the interim phase. A citizens' fire defense support fireman training program would be developed.

Cost. -- As with the Austere Program, development projects dominate the initial phase of the Moderate Program. Total OCD expenditures during the initial phase of the Moderate Program are estimated to be $479,100.

The Interim Phase

Protection Measures. -- Citizens' TV and radio information kits and inspecting and rating shelters would be implemented the same as in the Austere Program. Field procedures would be developed for infrared mapping and the program would be partly implemented. Field testing of tailor-made window shielding would be completed and part of the program would be implemented. A study would be made to determine the full effectiveness of using aerially-applied fire retardants to protect shelters.

Support Plans. -- The nuclear fire analysis system would be in full operation and nuclear fire analyses would be completed for many of the communities or planning areas during the interim phase. Guidelines for community planning would be developed as in the Austere Program. The national fire defense plan would be implemented identically as in the Austere Program. The nationwide fire intelligence system would be incorporated into the national fire defense plan. Professional fire staff leadership would be established at the national level to guide the technical aspects of the program and give services to field units. Plans would be prepared to guide the development of a nationwide fire communications system.

Training. -- Nuclear fire leadership training for nationally selected candidates would qualify 268 nuclear fire experts, and this would assemble a substantial segment of the nationally trained leadership needed to cope with nuclear fires. Rural fire defense training would be operational and work would continue with the states to train the required firemen. Fire Defense Support Fireman Training would be underway and be supervised by the state CD officials under the technical guidance of the fire services. By this time the Nuclear Fire Analysis will begin to define the number of support firemen needed.

Cost. -- OCD expenditures during the interim phase are estimated to be $29,615,600. The total 3-year — F. Y. 1966 through 1968 — OCD investment will be approximately $30,094,700. The Moderate Program's capability to protect lives and resources from fire risk will be partly developed by the end of F. Y. 1968.

The Full Development Phase

Protection Measures. -- Providing citizens' TV and radio information kits and shelter inspecting and rating measures remain the same as in the Austere Program. Tailor-made window shielding would be stocked in shelters in many cities by the end of F. Y. 1970. Publicity campaigns would be carried out, urging the people to have window shielding supplies ready in their homes and business places. As with the Austere Program, balance of the work would be accomplished after 1970. One-hundred-five infrared mapping units and 105 ground receivers would be operational by F. Y. 1970. The study of the effectiveness of aerial fire retardants to protect shelters will have produced findings for inclusion in the national fire defense plan.

Support Plans. -- Analyses for nuclear fires would be completed for all communities and planning areas in the United States by 1970, thus providing a sound basis for fire defense plans and a complete input for fire damage assessment. By 1969, community planning guidelines would be reducing the fire spread potential in urban areas; the nationwide fire intelligence system would be contributing substantially to life and resource-saving potential of organized fire suppression and rescue. Plans for implementing the nationwide fire communications system would be incorporated into the national fire defense plan. The national professional fire staff would be providing continuing leadership to the program.

Training. -- An additional 269 nuclear fire leaders would receive national-level training by 1970. Nationally trained nuclear fire leadership would then total 537 persons. After 1970, a total of 54 fire leaders would be trained each year to maintain this capability. Rural fire defense and fire defense support fireman training would continue as needed at the state and local level. A national fire technical staff support center would be established to convert quickly and effectively nuclear fire research findings to operational programs. This center would be supervised by the professional fire leadership staff mentioned earlier under Support Plans.

Cost. -- The total OCD investment in the Moderate Fire Defense Program is estimated to be $72,977,100 by the end of F. Y. 1970. By 1970, a substantial part of the program's capability to remove lives and resources from fire risk would be developed. The total OCD investment to fully implement the Moderate Program is estimated at $267,977,100.

THE COMPREHENSIVE FIRE DEFENSE PROGRAM

The objective of the Comprehensive Fire Defense Program (Table 8) is to utilize the full range of today's nuclear fire knowledge to protect all possible lives and resources from fire risk. Implementation time is compressed so that a complete state of readiness is achieved by 1970 in all measures, except smoke generation.

The Initial Phase

Protection Measures. -- The citizens' TV and radio information kits, shelter fire inspecting and rating, infrared mapping of nuclear fires, and the effectiveness study of aerial fire retardants for protecting shelters, are idential to the Moderate Program. Field testing of the smoke generation system would begin. Design and development of window shielding would be completed. This measure would be implemented only as necessary to support the smoke generation system.

Table 8

ELEMENTS OF THE COMPREHENSIVE FIRE DEFENSE PROGRAM

Protection Measures:

** 1. TV and radio information kit for Citizens' Fire Extinguishing and Prevention Program

2. Fireproof furnishings in buildings

3. Smoke generation

4. Window shielding (supplemental to smoke as needed)

** 5. Shelter Fire Inspection and Rating Program

** 6. Infrared mapping of nuclear fires

** 7. Study effectiveness of aerial fire retardants for protecting shelters

8. Study special equipment needed to suppress nuclear fires

Support Plans:

** 1. Nuclear Fire Analysis System

** 2. National Fire Defense Plan

* 3. Guidelines for community planning to minimize fire spread

* 4. Professional fire staff leadership

5. Standard Fire Service Radio Operating Procedures Handbook

6. Standard Fire Service Terminology for the U. S.

** 7. Nationwide Fire Intelligence System

** 8. Nationwide Fire Communications System

Training:

** 1. National Nuclear Fire Leadership Training

2. Local Nuclear Fire Leadership Training

** 3. Rural Fire Defense Training

** 4. Fire Defense Support Firemen Training

* 5. Fire Technical Staff Support Center

* Same item as Moderate Program but time phasing is compressed

** Same item, time phasing, and scope as Moderate Program

Support Plans. -- Field testing the nuclear fire analysis system and fire defense plans are the same as in the Moderate Program. Guidelines for community planning would be prepared during the initial phase. Professional fire staff leadership would be established. Plans to guide the development of a nationwide fire intelligence system would be prepared the same as in the Moderate Program.

Training. -- National nuclear fire leadership training and rural fire defense training programs are identical to proposals in the Moderate Program. Guidelines and samples would be developed to facilitate local nuclear fire leadership training. Fire defense support fireman training is identical to that in the Moderate Program.

Cost. -- As with the Austere and Moderate Programs, development projects dominate the initial phase of the Comprehensive Program. The groundwork is established for extensive life and resource saving capability. Total OCD expenditures during the initial phase of the Comprehensive Program are estimated to be $651,100.

The Interim Phase

Protection Measures. -- Provision of citizens' TV and radio information kits, shelter inspecting and rating, infrared mapping and studying the effectiveness of aerially-delivered fire retardants for protecting shelters, would be implemented identcally to the Moderate Program. Field testing would be completed for the smoke generation system and the program would be partly implemented. Effective ways would be developed to fireproof combustible furnishings in homes and other buildings. A study would be made to determine the optimum combination of equipment for successfully suppressing nuclear fires. Developing a universal fire hose connection would be part of this study, thereby making mutual aid more effective in fighting fires.

Support Plans. -- Achieving Nuclear Fire Analysis and implementing fire defense plans are the same as in the Moderate Program. OCD's community planning guidelines to minimize fire spread would be incorporated into state and local government programs. A national professional staff would be giving full leadership and service to the Program during the interim phase. A standard fire service radio operating procedure

would be prepared to improve communications. The nationwide fire intelligence system and communications systems would be developed and implemented identically to the Moderate Program.

Training. -- Training is the same as in the Moderate Program except that local nuclear fire leadership training and the fire technical staff support center would be implemented, in the interim phase.

Cost. -- OCD expenditures during the interim phase are estimated to be $78,911,600. The total for three years — F. Y. 1966-68 — will be approximately $79,562,700. The program's capability to protect lives and resources from fire risk will be partly developed by the end of F. Y. 1968.

The Full Development Phase

Protection Measures. -- All recommended protection will be fully implemented by the end of F. Y. 1970, except smoke generation. If needed, the citizens' TV and radio information kits would be readily available. Shelter fire inspecting and rating would be fully established. Full infrared mapping capabilities would be available. Householders would be prepared to fireproof furnishings. Preparations to defend shelters from fire by aerial means would be included in pre-emergency planning. Special equipment to suppress nuclear fires would be under

study and development. Implementing the remainder of the smoke screen measure would be completed after 1970. Time phasing would depend on available finances, public support, and the need established by the Nuclear Fire Analysis.

Support Plans. -- All support plans would be completed by the end of F. Y. 1970. The nuclear fire analysis system would in include a computer program in OCD with fire damage assessment capability. The national professional fire staff would be operating at full capacity, including management of the fire technical staff support center. Training materials, ideas, and expert services would be flowing from this center, adding strength to all aspects of the program. A standard fire service terminology would be developed to improve communications. Effective fire control intelligence and communication systems would be functioning. These support plans, plus the training mentioned below, will have made organized fire suppression and rescue fully effective.

Training. -- By 1970 training programs would provide the full complement of qualified citizens and professionals needed for the nuclear fire threat. The fire technical staff support center will help convert research findings to operational action rapidly and thoroughly. Maintenance of national nuclear fire

leadership training will continue to be supported by OCD. Local nuclear fire leadership training, rural fire defense training, and fire defense support fireman training would be continued on a maintenance basis by state and local CD officials and the fire services.

Cost. -- The Office of Civil Defense investment in the Comprehensive Fire Defense Program is estimated to be $196,001,600 by the end of F. Y. 1970. With these expenditures, a substantial portion of the program's capability to protect lives and resources from fire risk will be developed. The total OCD investment to fully implement the Comprehensive Fire Defense Program is estimated to be $758,689,100.

DEFINING THE OPTIMUM FIRE DEFENSE PROGRAM

The optimum fire defense program can be defined as the most effective combination of protection measures, support plans, and training that will reduce loss of life and resources from fire to acceptable limits at tolerable costs.

Throughout Phase One the study group searched for this optimum combination of measures. At first glance, the Comprehensive Fire Defense Program, with its potential capability to remove the fire threat to large numbers of lives, appears to

offer this combination. However, available data are not adequate to clearly define the optimum program. We do not know precisely how much loss of life and resources from fire can be tolerated and still maintain a capability for the United States to recover. The expenditure level at which investments for fire protection reach the point of diminishing return in comparison to investments in Military offensive and defensive weapons is not defined. Effectiveness of the recommended fire programs has been assessed only in terms of lives saved. Effectiveness of the programs in saving resources essential to recovery from an attack is yet to be analyzed. Finally, the state of development of the recommended protection measures is not advanced to the point that costs, feasibility, and effectiveness can be determined with certainty.

These shortcomings prompt the authors to recommend that OCD begin by implementing the Austere Fire Defense Program. Protection measures can be developed and tested, plans made, and methods and procedures tested during the initial and interim phases of the Program. Meanwhile, the life-saving capability and costs of the fire program can be compared with Military measures and a point of diminishing returns established. Perhaps a maximum acceptable expenditure to protect life and

resources can be established. Such an approach will probably disclose the optimum fire defense program to be a combination of elements of the Austere, Moderate, and Comprehensive Programs, including optimum cut-off points for dollars invested, lives protected from fire risk, and resources saved.

VIII. COST AND EFFECTIVENESS

Costs are estimated for each element in the recommended programs and these are totalled to determine the cost of the Austere, Moderate, and Comprehensive Programs respectively. Costs for each element are distributed between OCD, state and local governments, and the general public.

Effectiveness of each of the several recommended fire protection measures has been assessed in terms of sheltered lives protected from fire risk. It is assumed that shelter spaces will be occupied at the time of the attack. Effectiveness of each protection measure has been assessed individually except those concerned with organized fire suppression and rescue activities. The effectiveness of organized fire suppression and rescue activities, though significant, varies widely with type and duration of attack and is difficult to assess objectively. In addition to assessing the effectiveness of each recommended protection measure, the combined capability of the protection measures, support plans, and training has been assessed for the Austere, Moderate, and Comprehensive Programs. Effectiveness of the fire defense program for saving resources essential to the recovery of the Nation has not been assessed. Results of the

effectiveness analysis of the several fire protection measures and programs are available in the Analytical Report. (See References, page 176.)

Data used for determining costs are not contained in this report. These data are available in the National Fire Coordination Study files.

COSTS OF THE RECOMMENDED FIRE DEFENSE PROGRAMS

These programs contain the protection measures, support plans and training that embody the greatest potential for reducing the nuclear fire threat. Costs of each element included in the programs are listed in Table 9. Cost for the Austere, Moderate, and Comprehensive Programs are listed in Table 10. Expenditures are modest during the initial phase of each program, with a gradual increase in expenditures as methods are validated and experience is gained. Expenditures would reduce rapidly after the programs are developed to the full operational stage. Tables 11, 12, and 13 further refine the costs to OCD and show logistics and costs for developing and implementing each program element.

Table 9

COSTS FOR ELEMENTS OF RECOMMENDED PROGRAMS

1 ELEMENTS	2 OCD Cost to Develop	3 OCD Recurrent Cost	4 State & Local Government Cost	5 General Public (millions)	6 Total Cost
A. PROTECTION MEASURES					
1. Reduce Ignition Points					
(a) Citizens' Fire Extinguishing & Prevention Program	10,000	-	-	5.	5,010,000
(b) Treat or Cover Combustibles	35,000	-	-	900.	900,035,000
2. Reduce Thermal Effects					
(a) Smoke Screening	750,250,000	-	750,000,000	-	1,500,250,000
* (b) Window Shielding, Low-Cost	34,125,000	-	-	102.375	136,500,000
* (c) Window Shielding, Tailor-Made	260,000,000	-	-	1,040.	1,300,000,000
3. Reduce Fire Vulnerability of Fallout Shelters					
(a) Inspect and Rate Shelters	157,500	-	-	-	157,500
4. Organized Fire Suppression and Rescue					
(a) Infrared Mapping	3,796,000	-	3,796,000	-	7,592,000
(b) Determine Effectiveness of Aerial Fire Retardants in Protecting Shelters from Fire	53,000	-	-	-	53,000
(c) Determine Special Equipment Needs for Suppressing Nuclear Fires	49,000	-	-	-	49,000
B. SUPPORT PLANS					
1. Nuclear Fire Analysis System	1,329,500	-	11,731,500	-	13,061,000
2. National Fire Defense Plan	26,000	5,000	250,000	-	291,000
3. Guidelines for Community Planning to Minimize Fire Spread	24,000	-	-	-	24,000
4. Professional Staff Leadership	272,000	272,000	-	-	1,128,000
5. Standard Fire Service Radio Operating Procedures Handbook	19,000	-	-	-	19,000
6. Standard Fire Service Terminology	19,000	-	-	-	19,000
7. Nationwide Fire Intelligence System (Plan)	22,000	-	-	-	22,000
8. Nationwide Fire Communications System (Plan)	22,000	-	-	-	22,000
C. TRAINING					
1. National Nuclear Fire Leadership Training	713,100	71,310	-	-	713,100
2. Local Fire Leadership Training, develop guidelines	8,000	-	1/ -	-	8,000
3. Pilot Program for Rural Fire Defense Training	938,000	-	2/ -	-	938,000
4. Guidelines for Fire Defense Support Firemen Training	15,000	-	1/ -	-	15,000
5. Fire Technical Staff Support Center	-	(Cost Included in Professional Fire Leadership)			

* Window shielding is not needed when smoke proves effective.

1/ Costs to state and local governments to carry out the training are not estimated.

2/ OCD costs are to develop materials and conduct pilot programs. Costs to state and local governments to implement the training fully are not estimated.

Table 10

TIME-PHASED COST SUMMARY

FOR THREE ALTERNATIVE PROGRAMS

OCD COSTS

PROGRAMS	INITIAL PHASE	INTERIM PHASE	FULL DEVELOPMENT PHASE			
	F. Y. 1966	2-Year Total F.Y. 1967-68	2-Year Total F. Y. 1969-70	5-Year Total to 1970	Cost After 1970	Total Except "Continuing"
AUSTERE	$442,100	$6,640,925	$6,632,975	$11,716,000	$29,462,000	$41,178,000
MODERATE	$479,100	$29,615,600	$42,882,400	$72,977,100	$195,000,000	$267,977,100
COMPREHENSIVE	$651,100	$78,911,600	$116,438,900	$196,001,600	$562,687,500	$758,698,100

Table 11

TIME-PHASED SUMMARY OF OCD COSTS

AUSTERE PROGRAM

ELEMENTS	INITIAL PHASE	INTERIM PHASE			FULL DEVELOPMENT PHASE						Recurrent Annual Cost After Element is Fully Implemented
	F.Y. 1966	F.Y. 1967	F.Y. 1968	2-Year Total	F.Y. 1969	F.Y. 1970	2-Year Total	5-Year Total	Cost After 1970 to Complete the Measure	Total OCD Cost Except Recurrent Cost After 1970	
A. PROTECTION MEASURES											
1. Reduce Ignition Points											
(a) Citizens' Fire Extinguishing & Prevention Program (develop & implement)	10,000	-	-	-	-	-	-	10,000	-	10,000	-
2. Reduce Thermal Effects											
(a) Window Shielding, Low Cost (develop, test, and achieve 25 percent by 1970)	60,000	1,676,250	1,676,250	3,352,500	2,559,375	2,559,375	5,118,750	8,531,250	25,593,750	34,125,000	-
3. Reduce Fire Vulnerability of Fallout Shelters											
(a) Inspect and Rate Shelters (develop program guides, then implement)	57,500	25,000	25,000	50,000	25,000	25,000	50,000	157,500	-	157,500	-
4. Organized Fire Suppression and Rescue											
(a) Infrared Mapping (105 areas)	75,000	152,300	152,300	304,600	284,700	284,700	569,400	949,000	2,847,000	3,796,000	-
TOTAL PROTECTION MEASURES	202,500	1,853,550	1,853,550	3,707,100	2,869,075	2,869,075	5,738,150	9,647,750	28,440,750	38,088,500	-
B. SUPPORT PLANS											
1. Nuclear Fire Analysis System (50 percent by 1970)	26,000	159,687	159,688	319,375	159,687	159,688	319,375	664,750	664,750	1,329,500	-
2. National Fire Defense Plan (implemented by 1968)	11,000	15,000	15,000	30,000	-	-	-	41,000	continued operation	41,000	5,000
3. Guidelines for Community Planning to Minimize Fire Spread (by 1968)	-	-	24,000	24,000	-	-	-	24,000	-	24,000	-
4. Nationwide Fire Intelligence System (Plans) (by 1968)	-	-	22,000	22,000	-	-	-	22,000	-	22,000	-
5. Nationwide Fire Communications System (Plans) (by 1970)	-	-	-	-	22,000	-	22,000	22,000	-	22,000	-
TOTAL SUPPORT PLANS	37,000	174,687	220,688	395,375	181,687	159,688	341,375	773,750	664,750	1,438,500	5,000
C. TRAINING											
1. National Nuclear Fire Leadership Training (50 percent by 1970)	15,000	81,625	81,625	163,250	89,125	89,125	178,250	356,500	356,500	713,000	71,310
2. Rural Fire Defense Training (50 percent by 1970)	187,600	187,600	187,600	375,200	187,600	187,000	375,200	938,000	-	938,000	-
TOTAL TRAINING	202,600	269,225	269,225	538,450	276,725	276,725	553,450	1,294,500	356,500	1,651,000	71,310
TOTAL, AUSTERE PROGRAM	442,100	2,297,462	2,343,463	4,640,925	3,327,487	3,305,488	6,632,975	11,716,000	29,462,000	41,178,000	76,310

Table 12

TIME-PHASED SUMMARY OF OCD COSTS

MODERATE PROGRAM

ELEMENTS	INITIAL PHASE	INTERIM PHASE			FULL DEVELOPMENT PHASE						Recurrent Annual Cost After Element is Fully Implemented
	F. Y. 1966	F. Y. 1967	F. Y. 1968	2-Year Total	F. Y. 1969	F. Y. 1970	2-Year Total	5-Year Total	Cost After 1970 to Complete the Measure	Total OCD Cost Except Recurrent Cost After 1970	
A. PROTECTION MEASURES											
1. Reduce Ignition Points (a) Citizens' Fire Extinguishing and Prevention Program	10,000	-	-	-	-	-	-	10,000	-	10,000	-
2. Reduce Thermal Effects (a) Window Shielding, Tailor-Made	60,000	12,970,000	12,970,000	25,940,000	19,500,000	19,500,000	39,000,000	65,000,000	195,000,000	260,000,000	-
3. Reduce Fire Vulnerability of Fallout Shelters (a) Inspect and Rate Shelters	57,500	25,000	25,000	50,000	25,000	25,000	50,000	157,500	-	157,500	-
4. Organized Fire Suppression & Rescue (a) Infrared Mapping	75,000	304,600	1,138,800	1,443,400	1,138,800	1,138,800	2,277,600	3,796,000	-	3,796,000	-
(b) Determine Effectiveness of Aerial Retardants in Protecting Shelters from Fire	-	-	53,000	53,000	-	-	-	53,000	-	53,000	-
TOTAL PROTECTION MEASURES	202,500	13,299,600	14,186,800	27,486,400	20,663,800	20,663,800	41,327,600	69,016,500	195,000,000	264,016,500	-
B. SUPPORT PLANS											
1. Nuclear Fire Analysis System	26,000	325,875	325,875	651,750	325,875	325,875	651,750	1,329,500	-	1,329,500	-
2. National Fire Defense Plan (continued operation)	11,000	15,000	5,000	20,000	5,000	5,000	10,000	41,000	continued operation	41,000	5,000
3. Guidelines for Community Planning to Minimize Fire Spread	-	24,000	-	24,000	-	-	-	24,000	-	24,000	-
4. Professional Fire Staff Leadership	-	40,000	272,000	312,000	272,000	272,000	544,000	856,000	continued operation	856,000	222,000
5. Nationwide Fire Intelligence System	22,000	-	-	-	-	-	-	22,000	-	22,000	-
6. Nationwide Fire Communications System	-	22,000	-	22,000	-	-	-	22,000	-	22,000	-
TOTAL SUPPORT PLANS	59,000	426,875	602,875	1,029,750	602,875	602,875	1,205,750	2,294,500	-	2,294,500	277,000
C. TRAINING											
1. National Nuclear Fire Leadership Training	15,000	174,525	174,525	349,050	174,525	174,525	349,050	713,100	continued operation	713,100	71,310
2. Rural Fire Defense Training (on going)	187,600	375,200	375,200	750,400	-	-	-	938,000	-	938,000	-
3. Fire Defense Support Firemen Training	15,000	-	-	-	-	-	-	15,000	-	15,000	-
4. Fire Technical Staff Support Center	(Costs are included in Professional Staff Leadership, above, B. 4.)										
TOTAL TRAINING	217,600	549,725	549,725	1,099,450	174,525	174,525	349,050	1,666,100	-	1,666,100	71,310
TOTAL, MODERATE PROGRAM	479,100	14,276,200	15,339,400	29,615,600	21,441,200	21,441,200	42,882,400	72,977,100	195,000,000	267,977,100	348,310

Table 13

TIME-PHASED SUMMARY OF OCD COSTS
COMPREHENSIVE PROGRAM

ELEMENTS	INITIAL PHASE	INTERIM PHASE			FULL DEVELOPMENT PHASE						Recurrent Annual Cost After Element is Fully Implemented
	F.Y. 1966	F.Y. 1967	F.Y. 1968	2-Year Total	F.Y. 1969	F.Y. 1970	2-Year Total	5-Year Total	Cost After 1970 to Complete the Measure	Total OCD Cost Except Recurrent Cost After 1970	
A. PROTECTION MEASURES											
1. Reduce Ignition Points											
(a) Citizens' Fire Extinguishing & Prevention Program (develop kit)	10,000	-	-	-	-	-	-	10,000	-	10,000	-
(b) Treat and/or Cover Combustibles (develop method)	-	35,000	-	35,000	-	-	-	35,000	-	35,000	-
2. Reduce Thermal Effects											
(a) Smoke Screening (test effectiveness, then implement 25 percent by 1970) (10 percent by 1966)	100,000	37,462,500	37,462,500	74,925,000	56,268,750	56,268,750	112,537,500	187,562,500	562,687,500	750,250,000	-
* (b) Window Shielding, study feasibility (to be implemented only to support smoke screening, if feasible)	60,000	-	-	-	-	-	-	60,000	-	60,000	-
3. Reduce Fire Vulnerability of Fallout Shelters											
(a) Inspect and Rate Shelters (develop program and guidelines, then implement)	57,500	25,000	25,000	50,000	25,000	25,000	50,000	157,500	-	157,500	-
4. Organized Fire Suppression and Rescue											
(a) Infrared Mapping (develop procedures then implement for 105 areas)	75,000	304,600	1,138,800	1,443,400	1,138,800	1,138,800	2,277,600	3,796,000	-	3,796,000	-
(b) Determine Effectiveness of Aerial Retardants in Protecting Shelters from Fire	-	-	53,000	53,000	-	-	-	53,000	-	53,000	-
(c) Determine Special Equipment Needs for Suppressing Nuclear Fires (including hose hook-up and dispatching unit studies)	-	27,000	22,000	49,000	-	-	-	49,000	-	49,000	-
TOTAL PROTECTION MEASURES	302,500	37,854,100	38,701,300	76,555,400	57,432,550	57,432,550	114,865,100	191,723,000	562,687,500	754,410,500	-
B. SUPPORT PLANS											
1. Nuclear Fire Analysis System (develop and implement)	26,000	325,875	325,875	651,750	325,875	325,875	651,750	1,329,500	-	1,329,500	-
2. National Fire Defense Plan (test and develop samples, implement)	11,000	15,000	5,000	20,000	5,000	5,000	10,000	41,000	continued operation	41,000	5,000
3. Guidelines for Community Planning to Minimize Fire Spread	24,000	-	-	-	-	-	-	24,000	-	24,000	-
4. Professional Fire Staff Leadership (establish)	40,000	272,000	272,000	544,000	272,000	272,000	544,000	1,128,000	continued operation	1,128,000	272,000
5. Standard Fire Service Radio Operating Procedures Handbook (prepare)	-	-	19,000	19,000	-	-	-	19,000	-	19,000	-
6. Standard Fire Service Terminology (arrange)	-	-	-	-	-	19,000	19,000	19,000	-	19,000	-
7. Nationwide Fire Intelligence System (Plans) (Develop scope)	22,000	-	-	-	-	-	-	22,000	-	22,000	-
8. Nationwide Fire Communications System (develop scope & content)	-	22,000	-	22,000	-	-	-	22,000	-	22,000	-
TOTAL SUPPORT PLANS	123,000	634,875	621,875	1,256,750	602,875	621,875	1,224,750	2,604,500	-	2,604,500	277,000
C. TRAINING											
1. National Nuclear Fire Leadership Training (develop & implement by 1970)	15,000	174,525	174,525	349,050	174,525	174,525	349,050	713,100	continued operation	713,100	71,310
2. Local Fire Leadership Training. Develop Guidelines	8,000	-	-	-	-	-	-	8,000	-	8,000	-
3. Rural Fire Defense Training (on going) (Fully implement by 1968)	187,600	375,200	375,200	750,400	-	-	-	938,000	-	938, 000	-
4. Fire Defense Support Firemen Training	15,000	-	-	-	-	-	-	15,000	-	15,000	-
5. Fire Technical Staff Support Center (costs are included in B.4., Professional Staff Leadership)	-	-	-	-	-	-	-	-	-	-	-
TOTAL TRAINING	225,600	549,725	549,725	1,099,450	174,525	174,525	349,050	1,647,100	-	1,647,100	71,310
TOTAL, COMPREHENSIVE PROGRAM	651,100	39,038,700	39,872,900	78,911,600	58,209,950	58,228,950	116,438,900	196,001,600	562,687,500	758,689,100	348,310

* Population in Shelters

Development and field testing costs are assumed by OCD except for elements of the fire defense program in which other Government agencies have peacetime use for the measure. In this case the development costs are shared.

OCD's share of the cost of implementing each measure is determined by examining the nature of each protection measure, support plan, or training program; and prorating the costs on the basis of this examination. For example, OCD would assume the cost of developing and testing the materials needed to implement protection measure 1.(b), treating or covering combustibles. This measure would be done by the citizens, thus all implementing costs are assumed by the general public. A similar situation exists for the citizens' fire extinguishing and prevention program measure.

Some protection measures may be ideally suited for a cost-sharing program. In this event, estimates contemplate that OCD would pay 50 percent of the cost. Estimates of costs for window shielding assumes that OCD would stock supplies for shelters, with the general public assuming the cost of shielding windows in homes and business places. Costs for developing infrared mapping capability are distributed between OCD and other Government agencies. This distribution reflects the relation between peacetime and wartime needs.

The procedure explained in the above examples is used in distributing the costs of each protection measure, support plan, and training program. Back-up information is available in the National Fire Coordination Study files.

COSTS OF PROGRAM ELEMENTS CONSIDERED BUT NOT RECOMMENDED

Several measures, and combinations of measures, were analyzed in the recommended fire defense program but are not included by reason of the expense involved, or because the feasibility of implementing the measure seemed low. For instance, three types of window shielding were considered as possible protection measures for homes and shelters, but only two types of window shielding appear in the recommended program. These are the low-cost window shielding for all buildings in the Austere Program or the tailor-made window shielding for all buildings in the Moderate Program. Many other combinations were considered, but are not recommended.

Table 14 lists the individual protection measures, or combinations of protection measures that were analyzed, but were not included in the recommended program. Costs and effectiveness of some of these measures were analyzed by studies of the population in shelters, some with the population in residences, and some were analyzed for both situations.

Table 14

COST OF PROTECTION MEASURES CONSIDERED,
BUT NOT RECOMMENDED

Item No.	PROTECTION MEASURES	Total Cost($) (Millions)	Est. OCD Initial Cost ($) (Millions)
	POPULATION IN SHELTERS		
1	Window Shielding (Expensive) for all bldgs.	3,900	650
2	Window Shielding (Expensive) for Shelters Only	650	650
3	Window Shielding (Tailored) for Shelters Only	260	260
4	Window Shielding (Low Cost) for Shelters Only	026	6.5
5	Foam Extinguishers in Shelters (G)	1,500	undeter.
6	Window Shielding (Tailored) Plus Smoke Generators (A & B)	2,800	undeter.
7	Window Shielding (Tailored) Plus Foam Extinguishers for Shelters (A & G)	2,800	undeter.
8	Window Shielding (Tailored) Plus Smoke Screen, Plus Foam (A & B & G)	4,300	undeter.
9	Smoke Generators Plus Foam Extinguishers in Shelters (B & G)	3,000	undeter.
	POPULATION IN RESIDENCES		
10	Window Shielding (Expensive) all bldgs.	3,900	650
11	Householder Instruction Plus Noncombustible Window Covers and Home Fire Extinguishers (D)	600	300
12	Householder Instruction Plus Noncombustible Window Covers, and Treated Covers over Ignition Points (E)	500	undeter.
13	Householder Instruction Plus Upholstery Fire Retardants and Treated Covers for Ignition Points (F)	900	undeter.
14	Window Shielding (Tailored) Plus Householder Instruction, Noncombustible Window Covers, and Home Fire Extinguishers (A & D)	1,900	undeter.
15	Window Shielding (Tailored) Plus Householder Instruction, Noncombustible Window Covers, and Treated Covers over Ignition Points (A & E)	1,800	undeter.
16	Window Shielding (Tailored) Plus Householder Instruction, Upholstery Retardants and Treated Covers for Ignition Points (A & F)	2,200	undeter.

Item 1 covers an expensive type of window shielding designed to withstand more effectively the effects of initial blast, and follow-on blast from additional detonations.

Items 2, 3, and 4 cover the expensive, moderate, and low-cost window shielding for shelters only. Costs of these measures seem reasonable, but when compared to other measures, they do not have a potential to protect substantial numbers of lives from fire risk.

Item 5 considers the use of high-expansion foam generators in shelters. Its potential to protect lives from fire risk is substantial. Since the foam extinguishers would be used primarily in community shelters, much of the costs might be carried by OCD. This measure is not recommended at the present, but it shows enough potential to merit further study. (See page 47.)

Items 6 through 9 cover combinations of protection measures, some of which are individually included in recommended programs. The high cost of these measures (between 2.8 and 4.3 billion dollars) eliminated them from current consideration but they are worthy of further exploration.

Items 10 through 16 cover protection measures tested with the population in residences. Each measure has some potential to save lives from fire hazard, but the number of lives saved from fire risk is relatively low, and the cost per person saved from fire risk is high.

IX. IMPLEMENTING THE PROGRAM

The Office of Civil Defense would implement most elements in the recommended fire defense programs by designing and testing the elements, serving as a catalyst to launch the programs, and following up with support and supervision. The largest proportion of costs and effort would be assumed by state and local governments and the citizens. This arrangement permits spreading the financing and work load among many persons and organizations, thereby achieving life-saving capability without building up a large centralized staff.

THE ROLE OF THE FIRE SERVICES

Several public services will contribute to protecting lives from fire risk, and toward saving critical resources through concerted actions before, during, and after a nuclear attack. These fires cannot be coped with successfully without capable action by the citizens. The central core of these cooperative efforts are the organized fire services in the U S, and the state and local CD directors. State and local CD officials, guided by governors, mayors, and other elected leaders, are responsible for overall disaster coordination and leadership. The fire services, which are already in place and are highly trained to suppress peacetime fires, can play the key role in implementing the fire defense programs recommended in this report.

Fire services can lead in implementing each of the subject areas of protection measures, support plans, and training. For example, such necessary protection measures as shelter fire inspection, measures to reduce ignition from thermal flash, cleanup campaigns, and fire instructions to the public in times of stress, are logical actions for the fire services. Support and training tasks, such as training fire defense support firemen, assembling and analyzing fire data for pre-emergency planning, arranging static water supplies, preparing fire and rescue plans, arranging mutual aid and training to provide fire and rescue leadership for nuclear fires, are desirable tasks for the fire services.

The desirable role of the fire services during and immediately after an attack will be different in each community. Anticipated immediate attack effects, radioactive fallout, topography, fire susceptability, weather patterns, shelter locations, and other factors will influence their roles. Such factors should be considered when developing a plan of operations. Beginning on page 52, this report demonstrates that under certain conditions of attack, fire suppression and rescue alone can minimize fire risk to substantial numbers of lives, if the fire services are trained and organized for nuclear fire and if planning has been done thoroughly. Given this training, organization, and preplanning, the fire services have the capability to protect substantial numbers of lives from fire risk.

Numbers of persons saved from fire will vary depending upon the nature of the attack and the survival of fire service personnel. Training the fire services personnel to achieve rescue and selective fire suppression during a nuclear attack is the best way to develop initial life-saving capability quickly and inexpensively.

Organized action by fire services personnel is essential for saving resources needed during the post-attack recovery period. The effectiveness of organized fire suppression to save critical resources has not been analyzed, but peacetime experience suggests that it is significant.

IMPACTS ON EXISTING SYSTEMS

Implementing the recommendations would create impacts on the existing OCD system. These are described below.

Impacts on the Total OCD Organization

Fire, blast, fallout relationship. -- This study supports the need for fallout shelters and this need must be met first. However, it is demonstrated that the lives of significant numbers of survivors in shelters following a nuclear attack could be threatened by fire.

Financial Impacts. -- The recommended Austere Program requires a total OCD investment of $11,716,000 during the next 5 years. Assuming that OCD financing will remain at about the present level, the Austere Fire Defense Program investment is only 2.3 percent of the total funds available to OCD for the 5-year period. The Moderate Program requires a total OCD investment of $72,977,100 during the next 5 years. This investment is 14 percent of the total OCD budget for the period. The Comprehensive Program requires an OCD investment of $196,001,600 during the next 5 years. This is 38 percent of the total funds available to OCD for the 5-year period at present levels of financing. The Comprehensive Program cannot be fully implemented unless additional OCD finances become available.

Organizational and Staffing Impacts. -- Professional fire staff leadership at the national level is recommended to implement the technical aspects of the fire defense program. Organizational impact may be felt, if it is decided that the nuclear fire staff leadership is to be located in the Office of Civil Defense.

Impacts on the Priority Programs Included in Part B, Chapter 3, Appendix 2, Federal Civil Defense Guide.

Shelters. -- The recommended fire inspection and shelter rating would require special attention until existing shelters have been investigated. After this has been done, the inspecting and rating would become a routine part of the shelter designation. These inspections could uncover deficiencies that will require substantial work to correct. A marking program might be needed to designate shelters that are vulnerable to fire threat. Plans will have to be prepared to transfer occupants from the more vulnerable shelters to safer shelters if fire threatens. Supplies for shielding windows would become part of the shelter-stocking program.

Operational Plans, Direction, and Control. -- Implementing the recommended programs would create very little impact on existing procedures, except those procedures described in the fire and rescue annexes to the Federal Civil Defense Guide.

Increased Readiness Measures. -- The citizens' TV and radio information kits would facilitate readying the populace for the fire threat, and lessen the impact of pre-attack preparedness.

Emergency Services. -- Radiological monitoring and reporting would have to be expanded in or for the fire services to permit selective fire suppression and rescue activities until fallout intensity forces the fire services' personnel to take shelter. Fire and rescue services receive major impacts from the recommended programs. Local aspects of the Nuclear Fire Analysis would be accomplished by the fire services. Local and state fire defense plans would be altered sometimes as a result of the nuclear fire analysis and guidance from the national fire defense plan. Fire protection measures, support plans, and training would be implemented mostly by the fire services.

Other Impacts

The recommended fire defense programs require flexibility in coordination, adaptation, or work adjustments on the part of some Federal agencies, state and local governments, public services (i.e., fire, police, public works), national fire organizations, and the public.

It should be noted that impacts are of a "reduce work" nature as well as "create work" nature. For example, preparing and implementing a nationwide Nuclear Fire Analysis and a national fire defense plan - even though the initial effort must

be national - would ultimately achieve greater capabilities at the state and local level. This will lessen the need for effort and expenditure at the national level.

Other Federal Agencies. -- Coordination of effort between the several Federal agencies with defense responsibilities is the biggest task. Arrangements to achieve much of this coordination already exists in connection with other Civil Defense activities. The task ahead is to work the approved fire defense program into the existing framework of Federal responsiblities for Civil Defense.

State and Local Governments. -- The most significant impact on state and local governments appears to be in the area of fire defense planning, training, community planning, and public information.

In implementing the nuclear fire analysis system, both state and local governments would need to provide competent individuals to assist in applying nuclear fire planning guides to local situations. Once OCD has identified the nuclear fire problem areas and developed guidelines for local assessment of the problem, it would remain the responsibility of the state and local government units to provide follow-through efforts.

In developing a nationwide fire intelligence system, state governmental agencies may be asked to adapt their reconnaissance systems and communication networks to fire-damage assessment and make reports for their jurisdictional area. Any changes in this procedure would result in a definite impact on the present operating schedules. The amount of impact would depend, in part, on the method of transmitting intelligence information during wartime emergencies.

Both state and local governments would be involved in the development and application of guides for community planning to make fire defense following nuclear attacks more effective. Building codes, zoning regulations, urban renewal programs, and park planning are a few of the areas that, if given special consideration, could contribute to more effective planning in meeting the threat of urban and suburban fires.

State and local governments would assume a major share of the responsibility for providing information to communities on nuclear fire prevention measures and effective methods of interior and exterior shelter fire protection. Impact would be heavier in areas that have been previously identified as potential nuclear fire problem areas.

Public Services and Fire Organizations. -- These organizations and services play such a key role that they must participate actively in the planning and implementing of all aspects of the recommended programs.

The Public. -- Studies have demonstrated that the public services will need the help of trained members of the civilian populace in order to reduce the nuclear fire threat to acceptable limits. Responsibility for implementing important segements of several recommended measures rests with the citizens. Citizen support for the program, and citizen action to help implement it are necessary. Thus, there are major impacts on the citizens. Citizens should receive as much information about the nuclear fire problem as possible if they are to be knowledgeable and qualified to act without direct guidance.

X. SPECIAL PROBLEMS

Problems not clearly defined and problems related to, but beyond the scope of the NFCS, are discussed briefly in this section.

PROTECTING FIRE CONTROL EQUIPMENT FROM BLAST DAMAGE IN URBAN AREAS

Dispersing Fire Equipment on the Basis of Warning

The practice of dispersing equipment from probable target areas after a warning is advocated by some communities. The effectiveness of dispersing fire equipment from the centers of three major cities in the United States was studied during Phase One. The results are recorded in Table 15. In all three cities, equipment would have to be moved at least 10 miles to save 50 percent of the equipment during a light attack. A move of at least 25 miles is required for equal results in the assumed heavy attack. This information suggests that dispersement on the basis of warning would not be effective unless the dispersed equipment were sent to a place where some blast protection was available. The nuclear fire threat has a different meaning for each community. A Nuclear Fire Analysis would define the local situation clearly and provide a basis for deciding the best way to protect and use fire equipment during a nuclear attack.

Table 15. Usability of Deployed Equipment Following Heavy and Light Attack- (Three Cities)

Radius From City Center (miles)	Percent of Equipment Usable					
	Heavy Attack			Light Attack		
	City A	City B	City C	City A	City B	City C
5	0	1	0	50	45	45
10	1	20	0	65	66	56
15	40	33	1	90	66	47
20	59	33	1	99	74	50
25	71	51	12	99	99	54
30	75	72	24	100	99	90
35	76	90	36	100	100	99
40	85	96	50	100	100	99
45	94	-	95	100	-	100

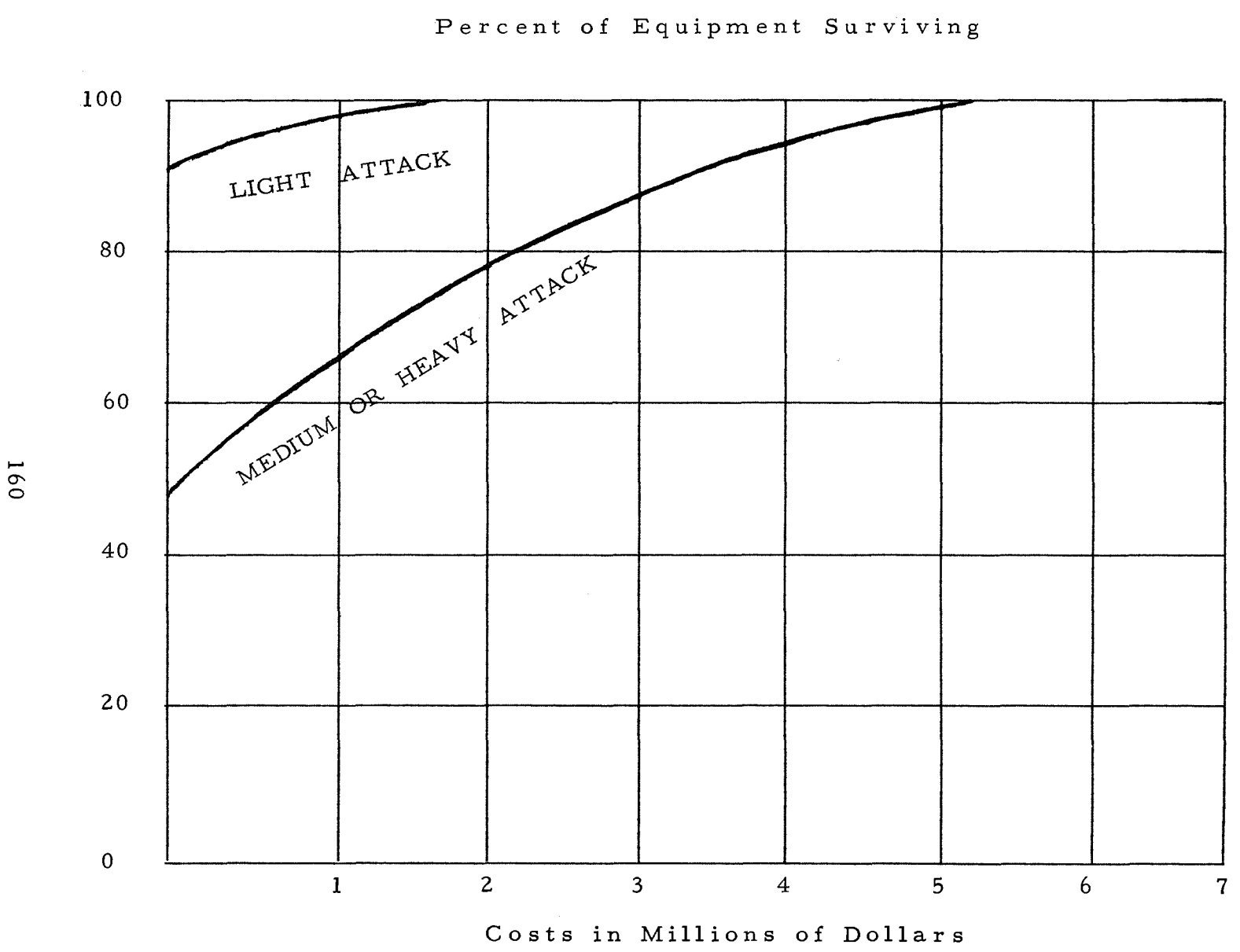
Blast Hardening of Firehouses

A study of blast hardening of firehouses in one large city shows that much fire equipment can be kept operable even during a heavy attack (Fig. 9). However, much of this saved equipment would be ineffective because debris and rubble from the blast would prevent its transfer and use. The recommended OCD fire program contains a study to determine the special equipment, or combinations of equipment, needed to control nuclear fires effectively. (See page 64.) If locally-situated equipment capable of controlling fires is recommended after this study, then the desirability of hardening some firehouses should be re-examined.

TACTICAL NUCLEAR DISASTER MANAGEMENT

Fire studies made by the investigative staff during Phase One disclosed the importance of arranging for capable command of the disaster as soon as possible following a nuclear detonation. Pertinent conclusions drawn were.

1. More detailed pre-emergency planning is needed for large fire emergencies that are more severe than have been experienced in the past. Pre-emergency planning is usually deficient in one or more of the following aspects:



160

FIGURE 9. Cost-Effectiveness of Hardening Fire Houses, One City (78 Installations)

a. resource inventories are not complete.

b. command responsibilities are not well defined.

c. deficiency exists in joint-training efforts.

d. no provisions are made for operational testing of cooperative organizations.

2. Rapid establishment of a strong central command should be emphasized. Urban fires rarely present such a problem because the general limits of the fire are predictable. This might not hold true of fires resulting from nuclear attack. Predicting ultimate fire size on wildlands, and hence the suppression forces needed to control the fire, is more difficult. Supervisory personnel crew members and equipment and supplies must frequently come from long distances to supplement initial attack forces. Volunteers, both trained and untrained unless directed, may go to work on a fire without reporting to fire headquarters, and may, leave without being released by fire headquarters. Command and coordination proved most effective when all agencies involved were represented by liaison personnel at the established fire headquarters.

3. Better coordination of effort is needed between fire services and Civil Defense organizations. Frequently the two groups come together only during a fire emergency and as a result the capabilities of both agencies are not fully realized.

These conclusions can be extrapolated to the nuclear attack fire environment by referring to the description of the study (p. 52) made of one city to determine the effectiveness of organized fire suppression and rescue. Under conditions of light attack, organized fire suppression and rescue efforts have a potential to protect a substantial number of lives within the urban population from fire risk, provided rapid and effective command is established and rapid and accurate fire intelligence is obtainable.

The mutual aid and command studies made during Phase One show that pre-emergency fire planning does not usually identify who would be in command of a fire or total disaster encompassing more than a single political jurisdiction. There is no lack of clarity on this point as long as the situation is local, and the local chief or his immediate neighbors can handle the fires. The problem arises when a disaster, or series of disasters of the magnitude that would accompany a nuclear attack, is contemplated.

Fire defense plans explained earlier in this report, if fully implemented, will help to assist arrangements of the nuclear disaster fire command. The important elements of maintaining or achieving competent command during and immediately after an attack have not been dealt with fully. This is because tactical command will have to cover all elements of the total disaster. The job is broader in scope than the fire function and is somewhat beyond the scope of this report.

REFERENCES

These references are not available for general distribution. Persons who have special interest in them should contact the Office of Civil Defense, Department of the Army, Department of Defense, Washington, D. C.

PRIMARY REFERENCE

Analytical Report, NFCS report by William R. Moore, James W. Jay, and John H. Dieterich, March 1965, Classified, "Confidential".

Support and Supplementary Documents to the Primary Reference

1. Problem Solving in the Analytical Phase, NFCS Report by Staff, 1964.

2. Analysis of Past Recommendations, NFCS Report by William R. Moore, 1964.

3. Fire Service Briefing Meetings, NFCS Report by William R. Moore, 1964.

4. Combined Mutual Aid Analysis, NFCS Report by William R. Moore and J. W. Jay, 1964.

5. Research Summary and Analysis, NFCS Report by T. G. Storey and J. H. Dieterich, 1964.

6. Combined Fire Analysis, NFCS Report by J. H. Dieterich, 1964.

7. Study of Nevada Fires, by J. W. Jay, August 1964.

8. Study of Park Headquarters Fire, by J. H. Dieterich, September 1964.

9. Study of Deadwood Fire, by J. H. Dieterich and D. B. Gratz, September 1964.

10. Study of Santa Rosa Fires, by T. G. Storey, September 1964.

11. Study of Mutual Aid and Command in the Portland, Oregon Area, by Les Colvill, September 1964.

12. Study of Mutual Aid Systems in New England, by Bio-Dynamics, Inc., October 1964.

13. Study of Mutual Aid and Command Situations in Michigan, by Keith Royer and Floyd Nelson, October 1964.

14. Study of Mutual Aid and Command for Large Fires in the Los Angeles Area, by T. G. Storey and C. L. Harrison, October 1964.

15. Study of Mutual Aid and Command Arrangements in the Washington, D. C. Metropolitan Area, by J. W. Jay and R. E. Lockhart, October 1964.

16. The Fire Problem in Nuclear War, by System Sciences Co., December 1964, Classified "Confidential".

APPENDIX

A. DEFINITIONS

The following definitions are applicable to this report.

1. Fire Defense.

   The total concept of defending the lives of people from fire and protecting property and resources needed for recovery of the Nation during an enemy attack.

2. Fire Defense Program.

   The combination of extraordinary preparation and operations employed to prevent, contain, or control the destructive effects of fires during an attack.

3. Fire Services.

   Organized urban and rural fire departments and services who are currently engaged in preventing and suppressing fires.

4. Fire Organization.

   Oragnizations whose primary objectives are to support the fire services, establish fire standards, or increase the professional ability of fire services.

5. Urban Areas.

   Towns, cities, or municipalities under the jurisdiction of organized municipal fire departments.

6. Rural Areas.

   Forests, other wildlands, flammable crop lands, and communities not under the jurisdiction of organized municipal fire departments.

7. Protection Measures.

Active and passive measures applied on-site to prevent, control or plan control of fires including measures to: reduce ignition points; reduce thermal effects; reduce the vulnerability of fallout shelters to fire; and organized fire suppression and rescue activities.

8. Support Plans.

Plans or guides necessary to execute the protection measures, including off-site staff support and service.

9. Nuclear Fire Analysis.

An analysis of the nuclear fire threat to each community, an inventory of each communities' capability to cope with the threat, and an evaluation of the effectiveness of alternative protection measures for each community.

10. Nuclear Fire.

Fire caused by primary ignitions from thermal energy plus subsequent spread.

11. Fire Threat.

The fire threat to lives and resources stemming from nuclear attack complicated by accompanying blast and fallout.

12. Nuclear Fire Problem.

The total problem presented by nuclear fire including the fire threat and the problems of coping with the threat under conditions imposed by blast and fallout.

13. Lives Exposed to Fire Risk.

Persons threatened by fire to the extent they are forced to choose between defending themselves from fire or fleeing shelter and risking possible death or serious illness from radioactive fallout.